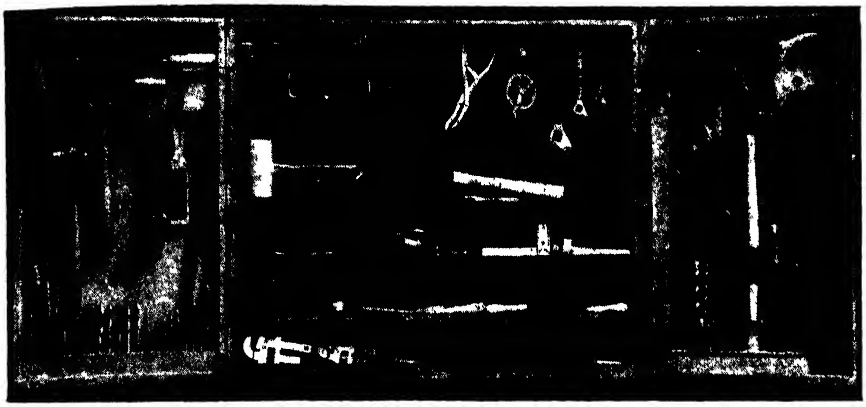

ON THE FARM

by MACK M. JONES

McGRAW-HILL BOOK COMPANY, INC.

New York Toronto London

About the Author

Thirty-five years of experience as a teacher of farm shopwork qualifies Mack M. Jones as an expert on the subject. He grew up on a farm in Oklahoma, where as a young man he spent considerable time operating, maintaining, and repairing farm machinery and equipment.

Mack Jones joined the staff of the University of Missouri as an instructor in 1919 and soon after he was given charge of courses in farm shopwork and in farm power and machinery. He later became a professor and chairman of the Department of Agricultural Engineering.

Over the years he has trained hundreds of practical farmers and vocational agriculture teachers in farm shopwork. Indirectly through his well-illustrated and well-written books he has instructed thousands of students and farmers throughout the country.

Professor Jones is an ardent amateur photographer. His hobby not only gives him personal pleasure, but helps him in gathering and developing illustrations for use in his classes and his books. Most of the drawings in this book were developed from pictures which he took.

SHOPWORK ON THE FARM

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PREFACE

SHOPWORK ON THE FARM was originally prepared to serve as a text and reference book for students of agriculture, farmers, and teachers. This revised edition continues and extends that same objective. It deals simply and directly with tools, materials, operations, and processes or activities, rather than with specific jobs or projects. It can be used, therefore, with any mechanical jobs or projects that suit individual abilities and needs. These may be related to the home, the farm, the school, or the student's special agricultural interests.

Emphasis throughout is placed on correct methods, together with the underlying reasons, or the *why*. Only by understanding the why can a learner master a subject or use acquired knowledge effectively in the solution of his own problems.

Many new illustrations have been added; others have been replaced with more up-to-date representations. All of them show methods of using tools and performing basic shop operations; often the illustrations re-emphasize in picture form the explanations given in words. Summaries of hints and practical pointers are included on various topics such as sharpening saws, hack sawing, drilling in metal, and welding. Considerable new material has been added on the subject of welding.

Satisfactory achievement in shopwork calls for reading and study on the part of the student, in addition to manual work and skill development. Much assistance is available in these pages that will help to answer mechanical questions and solve difficulties as they may arise. Consulting this book is a means of self-help which develops resourcefulness and self-confidence in the individual. *Shopwork on the Farm* thus supplements the work of the instructor and constitutes an invaluable teaching aid.

This book is not only of value in both high-school and college classes but should also find its way into the home libraries of farmers of all ages.

MACK M. JONES

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Special acknowledgment is due to my daughter Virginia for the art work in many of the illustrations; to Mr. C. L. Day and Mr. J. S. McKibben, of the Department of Agricultural Engineering, University of Missouri, for suggestions and critical reading of portions of the manuscript; and to Mr. W. A. Ross, Consulting Editor, for his patient and constructive work on the manuscript.

MACK M. JONES

Text-Films for SHOPWORK ON THE FARM

The following series of 12 filmstrips, entitled *Shopwork,* has been prepared by the Text-Film Department of McGraw-Hill Book Company, Inc., to correlate and to illustrate visually specific items in this book.

Set 1

- Care and Repair of Hand Tools
- Sharpening Hand Tools
- Sharpening and Using Auger Bits and Twist Drills
- Sawing, Planing, and Smoothing Wood
- Laying Out Common Rafters and Open Stairs
- Soldering

Set 2

- Filing and Hacksawing
- Blacksmithing
- Oxyacetylene Welding and Cutting
- Electric Arc Welding
- Pipework and Simple Plumbing
- Using Electricity Safely

Detailed descriptions of these filmstrips are given in the Correlated List of Visual Aids on pages 609 to 616.

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CONTENTS

EDITOR'S FOREWORD

THE GROWING of crops, the raising of animals, and the marketing of agricultural products include an increasing number of mechanical jobs. Such jobs must be well performed in order to reach a satisfactory standard of production and financial return. Along with these responsibilities is that of maintaining an efficient and satisfying farm home and surroundings. Involved are the mechanical planning and skill to repair, replace, recondition, and construct which make the American farmer an unspecialized mechanic.

Since mechanical work must be performed with the aid of tools and power, a well-planned and appropriately equipped shop is a necessity on every farm, ranch, and plantation. The continuing increase in mechanization and the trend toward more power tools and equipment bear testimony to the important place of mechanics and shopwork in most agricultural operations. The modern agricultural business must be kept in good running condition; otherwise feed and food production costs become excessive. Time, inconvenience, and money are saved with a good shop, properly used.

As in the first edition, outstanding features of this book include the very practical and direct approach made by the author, the logical activity basis of subject-matter organization, the understandable language used, and the story told both in the words and in the many well-selected illustrations provided. No reader can fail to sense the unique ways suggested for performing certain jobs and parts of jobs, and the ease with which information can be located.

The author, Professor Mack M. Jones, is well known in the fields of agricultural engineering and farm shopwork. His writings include books, bulletins, and technical articles. For years he has been engaged in training teachers of mechanical subjects on both the secondary and college levels. This revised edition of *Shopwork on the Farm* comes from the pen of a man whose patience and painstaking work have been welcomed by student, farmer, teacher, and householder with genuine enthusiasm.

W. A. Ross

1 PLANNING AND EQUIPPING A HOME FARM SHOP

1. Selecting the Site
2. Planning the Shop Building
3. Selecting Tools, Equipment, and Supplies
4. Arranging the Interior and Storing Tools
5. Storing Supplies and Materials
6. Providing Facilities for Servicing Tractors and Machinery
7. Practicing Safety in the Shop

IN ORDER to keep farm machinery, buildings, and equipment in good repair, a workshop of some kind is essential. It need not be elaborate and expensive, but it should be orderly and systematic. Ample room is necessary for working on machines, and a system should be followed for storing and protecting the shop tools and keeping them where they can be readily found when needed.

With the increased mechanization of farms, it has become necessary for the successful farmer to be proficient in the use, repair, and maintenance of mechanical equipment of various kinds. Although some farmers are expert mechanics, the majority of them need be only general mechanics, not experts. It is usually much better for the average farmer to depend upon well-equipped commercial shops for his specialized needs, such as the complete overhaul of tractors and the repair of complicated electrical equipment.

Although the farmer needs to be only an unspecialized mechanic, he should nevertheless be a good one, and he should be thorough. Slovenly or slipshod methods have no more place on the farm than in other

businesses or occupations. Machinery that works well, gates that open and shut easily, and buildings and fences that are orderly and in good repair not only save time and money for the farmer, but contribute to morale and pride of ownership.

1. SELECTING THE SITE

The best location for the farm shop will depend upon the location and arrangement of other buildings and the fences and lanes on the farmstead, as well as the desires of the individual farmer. Locate the shop handy to machines and implements as they are taken to or brought from the field. It is desirable also to have the shop near paths or routes that are regularly used by the farmer as he goes about his daily work, so that small pieces of equipment can be readily taken there for repairs. On most farms, an ideal location for the shop is in or attached to the machinery building. Other factors to be kept in mind when selecting the site for the shop are the general appearance of the

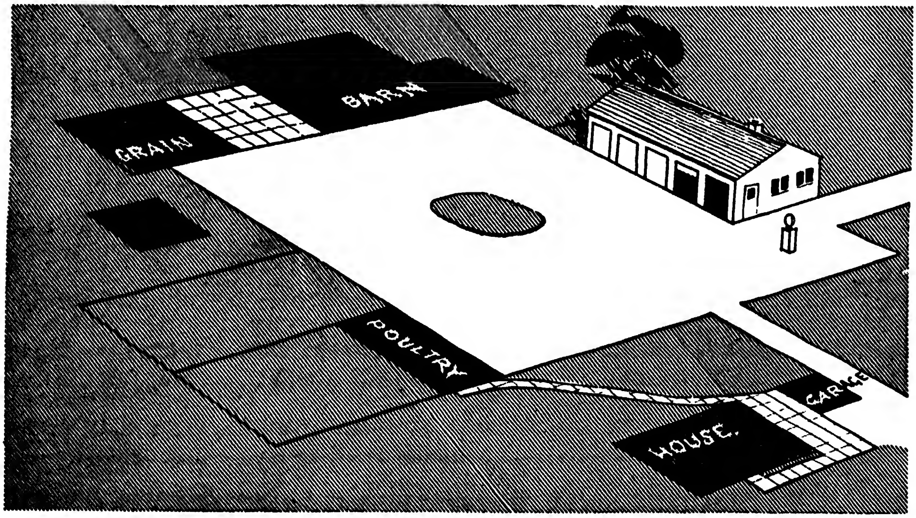


Fig. 1-1. A good location for the shop and machinery building is on one side of a service court where it is easily reached from the fields and from the farmyard.

farmstead, location of windbreaks, drainage, space around the building, protection from winter winds and drifting snow, and the possibility of future additions. One good arrangement for the farm shop and machinery building in relation to other buildings on the farmstead is suggested in Fig. 1-1.

In case a large, complete shop cannot be afforded, the shop can often be started in some seldom-used building, such as an old shed or perhaps a part of a barn. A place for a bench and the orderly arrangement of some tools and supplies, although not wholly adequate, will be much better than no shop at all. As finances or conditions warrant, the shop can be enlarged and moved to more adequate quarters. Starting with a few good tools and a place to keep and use them, and then adding to the collection from time to time, is a very practical way of acquiring satisfactory shop facilities on a farm. It is not often that a farmer can afford to build and outfit a shop completely at the outset.

2. PLANNING THE SHOP BUILDING

Although farm shop buildings are not standardized, there are three general classes: shops combined with machinery buildings, shops combined with garages, and separate shop buildings. The type to choose for

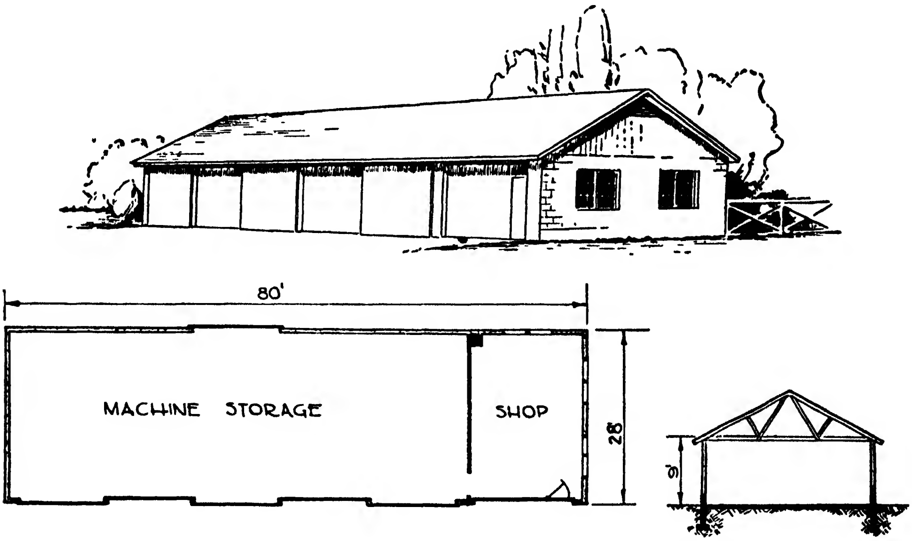


Fig. 1-2. A typical combination shop and machinery building.

a particular farm will depend principally upon other existing buildings and their arrangement.

For convenience and economy the shop is most often located in or attached to the machinery building. Such an arrangement is shown in Fig. 1-2. Sometimes it is feasible to combine the shop with a garage.

The car, truck, or tractor that is normally housed in the garage can usually be removed for a few hours, or even a few days, when extra space is needed for repair or construction work. A separate shop building is seldom the most practical type.

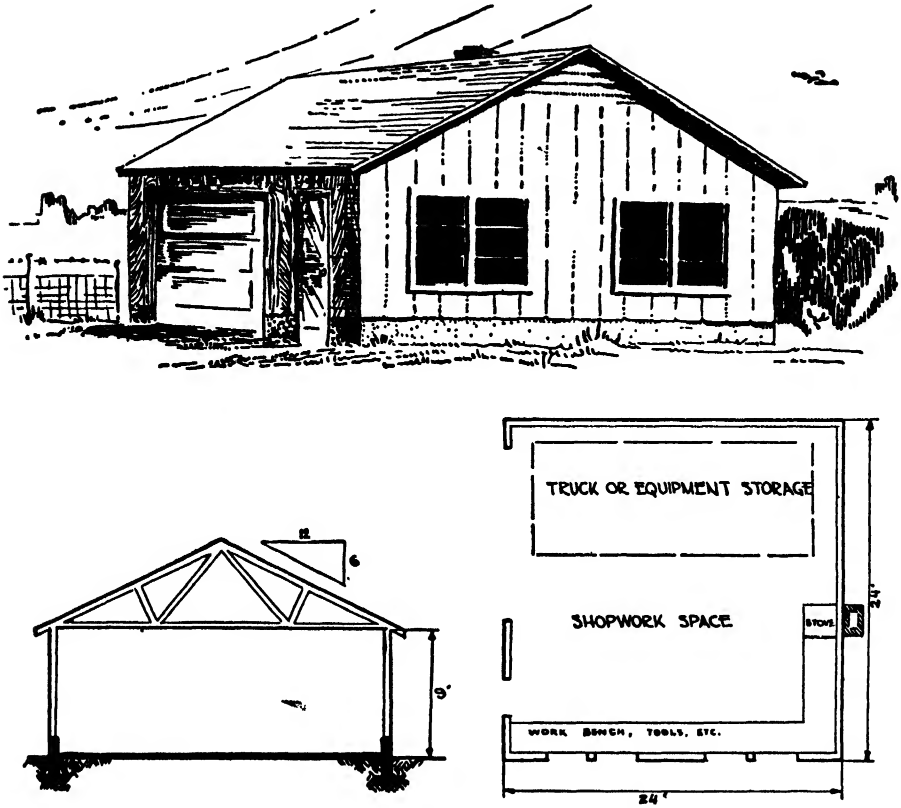


Fig. 1-3. Although the shop should generally be a part of the machinery building, it is sometimes more practical to combine it with a garage for a truck or tractor.

Determining the size of the shop A floor space of about 14 by 20 ft is usually adequate for most farm shop needs, especially if other nearby space is available for machines while being repaired. Spaces 20 to 24 ft wide by 24 to 32 ft long are usually ample for reasonably complete shop equipment and repair space.

Planning the foundation and floor Concrete is the most satisfactory material for the foundation. Use either poured concrete for both the footing and the foundation wall, or poured concrete for the footing and concrete blocks or other masonry for the wall (see Fig. 1-4). Ex-

tend the foundation down in the ground to firm soil and below the frost line. The exact depth varies considerably in different locations, and may be determined by consulting local builders. The minimum depth should be 18 in. Extend the foundation above the ground at least 12 in. to protect the building against ground moisture.

Concrete makes an ideal floor for the shop and should be used wherever possible. To ensure dryness, grade up the floor level inside the building so that the top of the finished floor will be 6 to 8 in. above the outside ground surface. Make concrete floors at least 5 in.

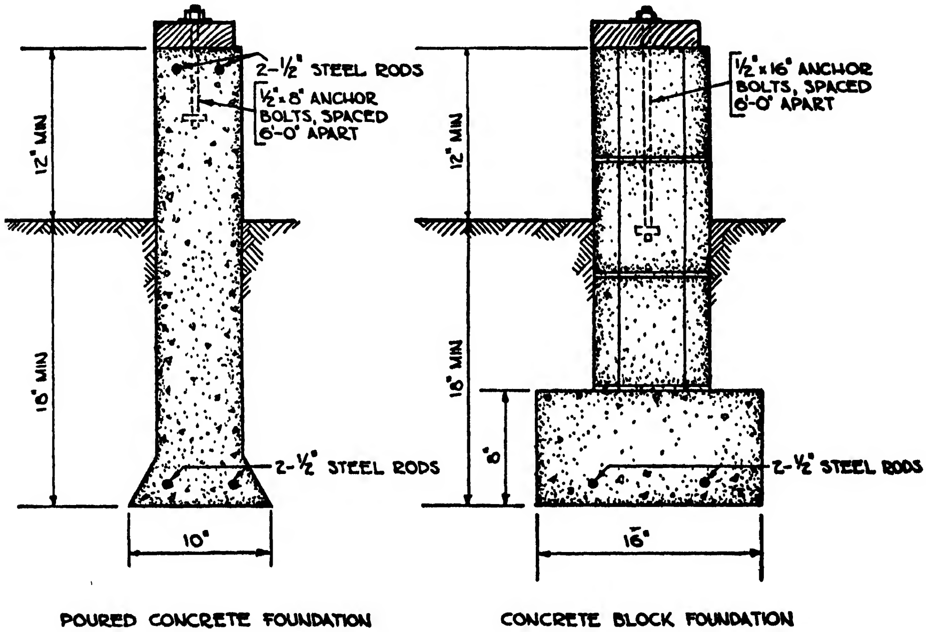


Fig. 1-4. Construction details for concrete footings and foundations.

thick where machinery is to be stored or moved. Where some saving in cost is imperative a tamped earth floor, or a 6-in. layer of gravel or crushed rock, can be used. Cinders are not satisfactory. They are gritty and dusty and tend to cause rusting. Use a concrete approach in front of doorways.

Choosing building materials The farm shop may be of frame construction or of brick, tile, or concrete blocks. The choice of materials will be determined by comparative costs, the preference of the owner, the materials used in other buildings on the farmstead, and the materials available. Brick, tile, and concrete are more fire-resistant than

wood construction, although the fire hazard in any shop can be reduced by careful planning, by prompt disposal of rubbish, and by keeping the shop clean and orderly.

Planning for windows and doors Provide plenty of light and ventilation in the shop by putting windows on two sides, or on three sides if possible. Place one window over or near the workbench. If there is a vise on each end of the bench, a window over each is desirable. For an average-sized shop, four windows, each with six 10- by 12-in. panes, are usually adequate.

A good farm shop should have one large door with an easy grade entrance for bringing in moderate-sized machinery, and an ordinary service door about 2 ft 8 in. wide so that the large door will not have to be opened every time one enters the shop. While a standard-sized garage door (8 ft wide by 7 ft high) might be adequate for the large door, one somewhat larger will be justified in most cases. The large door may be of the large double type with two doors which swing out, or of the rolling type, or of the overhead type. In most cases, it will probably be more satisfactory to use rolling doors than hinged doors. Overhead doors are probably best where the extra cost can be justified. In any case, the doors should be tight-fitting when closed so as to keep out drafts and birds, and it is essential that they be easily opened and closed.

Wiring the shop Allow for generous use of electricity in the shop. Good lights will encourage and facilitate work on dark, rainy days when outside work cannot be done. At the time of wiring, there is frequently a tendency to underestimate the needs for lights and outlets for small appliances and electrically operated tools.

It is usually advisable to install a 60-ampere (amp) service entrance with at least four branch circuits. Besides the 115-volt circuits for lighting and small appliances, a separate 230-volt circuit with heavy wiring will be needed for an electric welder and for motors larger than ½ horsepower (hp).

The following general suggestions will serve as a guide in providing adequate electrical service for the shop:

1. For general lighting in the shop, use ceiling lights controlled by a wall switch near the door.

2. Put lights over work centers, such as the workbench, welder, power saw, and drill press. Use a pull switch for each light. Locate them to avoid shadows on the work spaces.
3. Install convenience outlets at work centers and at several other places in the shop for attaching power tools and trouble lamps.
4. Put the connection for the arc welder near the door so that work can be done on machines outside the shop.
5. Use No. 12 wires, or even No. 10, for the 115-volt wiring.
6. Install an outside light on a pole or on the shop building to light the shop entrance and to facilitate an occasional job of nightwork.
7. Use only approved wiring and appliances—those that have labels showing approval by the Underwriters' Laboratories.
8. Be sure to follow safety codes, rules, and regulations. Have all wiring done by competent electricians.

Heating the shop Some method of heating is needed to provide comfortable working conditions in winter. A circulating heater using liquefied petroleum gas or oil is particularly good, because it can be turned off when you leave the shop. A coal or wood stove is practical under many conditions.

Use a masonry flue with a liner or a flue of cement-asbestos or other approved material, for a stove or a forge. Approved vents should be used with gas heaters. Where both a stove and a forge are to be used, a double flue is desirable. Both can be connected to the same flue, however, and yet afford reasonably good control of drafts, if each is equipped with a damper. If wood or coal is burned, use a spark arrester on top of the flue.

Locate the stove where grease, shavings, and rubbish can be easily kept away from it.

3. SELECTING TOOLS, EQUIPMENT, AND SUPPLIES

A practical way to build up suitable equipment for a shop is to clean and repair such tools as are already about the place, and then buy others from time to time as needs develop and the expense can be justified. In general, buy good or top-quality tools rather than cheap or limited-capacity tools. It is usually false economy to buy the cheapest grade of tools for farm shop work.

It is a good plan to start off by acquiring a good set of basic hand

tools for general work, such as a steel square and folding rule, crosscut handsaw and ripsaw, bit brace with an assortment of auger bits and drills, hack saw, screw drivers, wrenches, pliers, hammers, chisels and punches, files, wrecking bar, plane, bench vise, and other common tools.

Power tools such as a grinder, portable electric drill with a drill stand or a drill press, an electric arc or oxyacetylene welder, a power wood saw, and possibly a power hack saw, can be added to the shop equipment as needs arise until finally adequate equipment is accumulated.

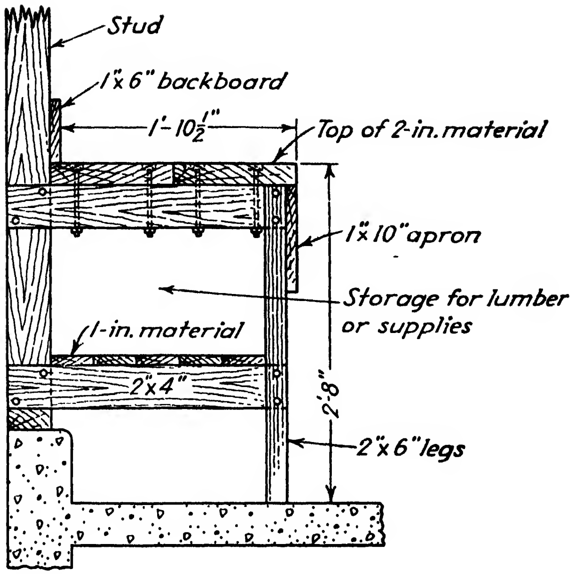
Special needs may warrant the purchase of more elaborate tools and equipment, such as a hoist, air compressor, threading and plumbing tools, a lathe, or a greater variety of small tools for carpentry, metalwork, or machinery repair.

Before making major purchases of equipment, study catalogues and examine stocks in supply and hardware stores in order to determine most suitable sizes, grades, or types of tools for your particular needs. Observing tools and equipment in use in other shops is often helpful.

Making shop equipment and fixtures Much of the shop equipment like workbenches, sawhorses, nail and tool boxes, storage racks, shelves, and drawers can be made easily in the shop. These may be as simple or as elaborate and extensive as space allows or as the owner may desire.

Workbenches The workbenches need to be rugged and sturdy. If possible, build stationary workbenches into the wall or attach them to the wall. Sometimes the wall studs can be used to support the back of the bench (see Fig. 1-5). Use 2-in. lumber for the top of the bench. For the legs and main supports, use 2-in. lumber also, or else use a welded angle-iron framework. Use bolts and screws rather than nails for fastening the parts of a bench together.

Make benches 24 to 30 in. wide. Benches that are too wide make it difficult to reach tools or supplies in cabinets or on shelves above the bench. Also, there is more tendency to pile tools and materials on a wide bench instead of returning them to their proper places. Make benches 30 to 34 in. high. The length of a built-in or stationary bench may be 6 to 12 ft, depending upon the space available and the desires of the owner. Benches are often made longer than necessary. It is much better to have a small bench with cabinets, bins, and shelves



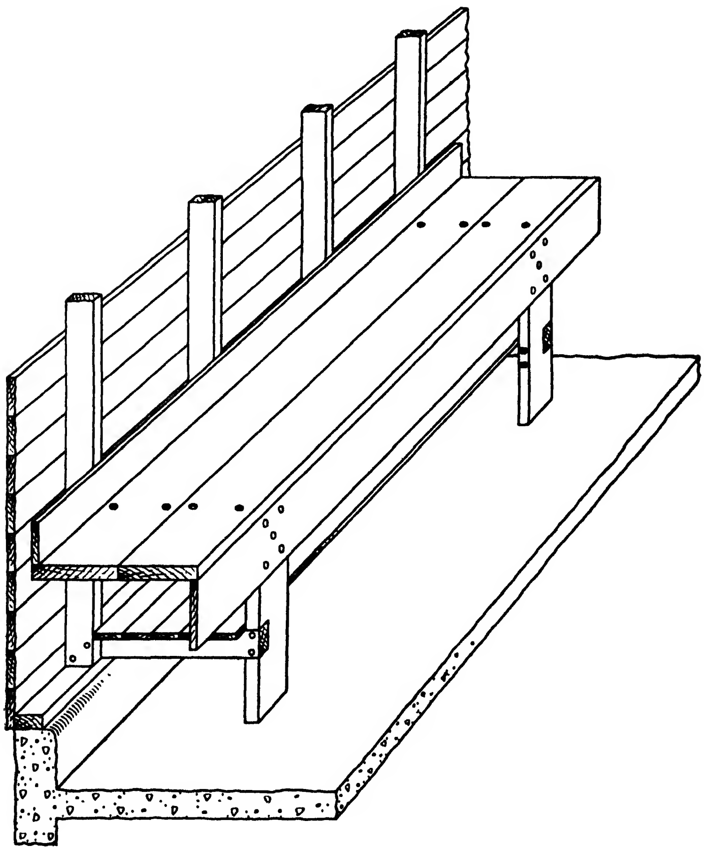


Fig. 1-5. A substantial built-in workbench can be made easily in the shop.

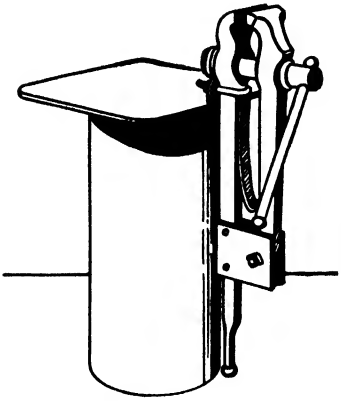


Fig. 1-6. A good way to mount a blacksmith's vise. Cut a section from an old range boiler or large pipe and set it in the floor. Then on top mount a small table of steel plate.

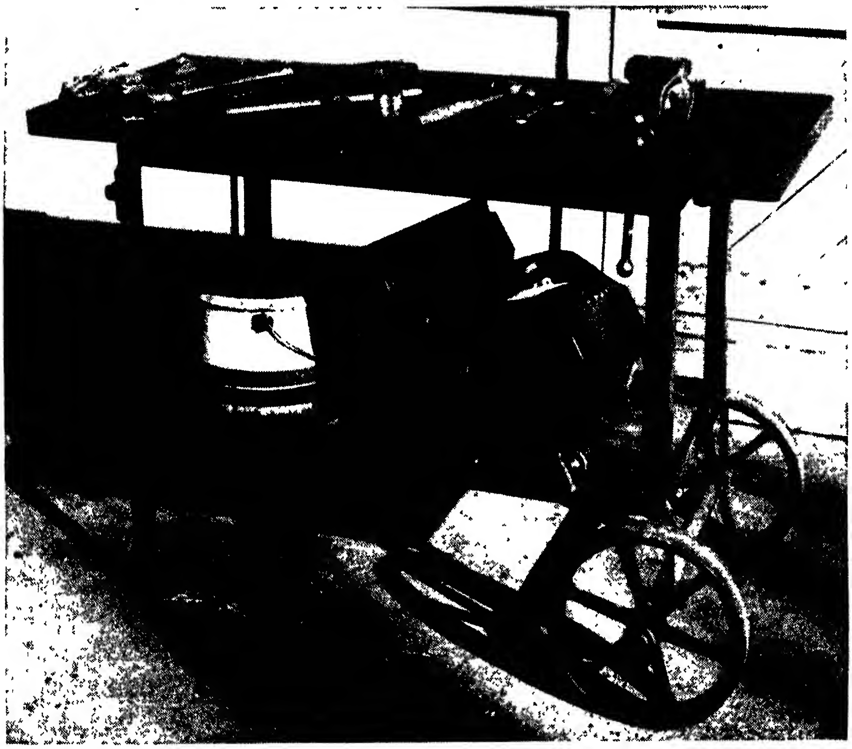


Fig. 1-7. A portable workbench is particularly useful for repairing and adjusting farm machines either in the shop or outside.

arranged conveniently about it than to have a large bench that is cluttered with tools and materials because there is no regular place for them.

In addition to a stationary bench, a portable one with small wheels under one end is very convenient (see Fig. 1-7). A good size for such a bench is about 3 ft long, 20 in. wide, and 32 in. high.

4. ARRANGING THE INTERIOR AND STORING TOOLS

It is best to place the workbenches and larger, heavier pieces of shop equipment along a side of the shop, or at one end, or both along one side and one end, in order to leave a large unobstructed space to accommodate implements and machines being repaired or larger pieces of equipment being constructed. It is usually a good plan to put woodworking tools and equipment about one bench and metalworking tools about another; or if only one bench is used, woodworking equipment at one end and metalworking equipment at the other end. Wherever

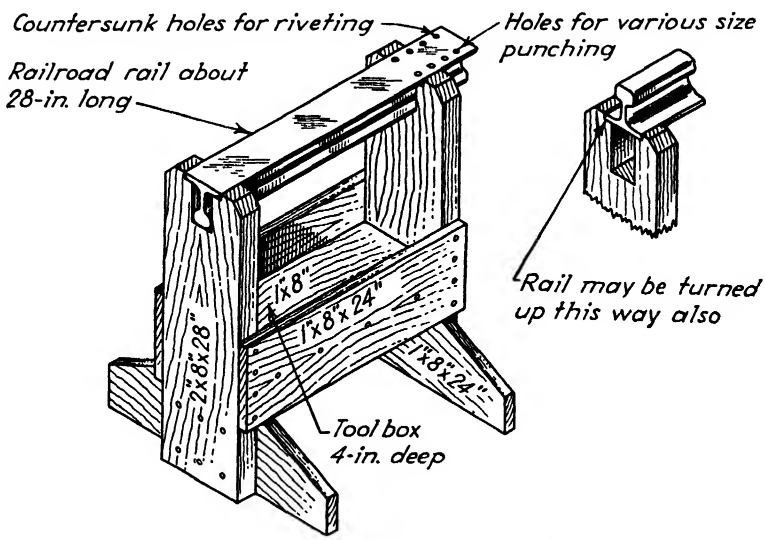


Fig. 1-8. A piece of railroad rail mounted on a stand makes a practical lightweight anvil.

possible, put tool cabinets or racks near benches or other places where the tools will be most frequently used.

The locations of windows and doors will have an important bearing on the location of benches and the larger pieces of equipment. Good light at work centers is important.

Arranging tool cabinets and tool boards Keep tools where they can be easily and quickly found when needed and easily and quickly replaced after a job is finished. Both closed cabinets and open tool boards or racks are used with success in farm shops (see Figs. 1-10 and 1-11). Cabinets that can be closed are usually preferred for the smaller and more expensive tools, as they give better protection against dirt

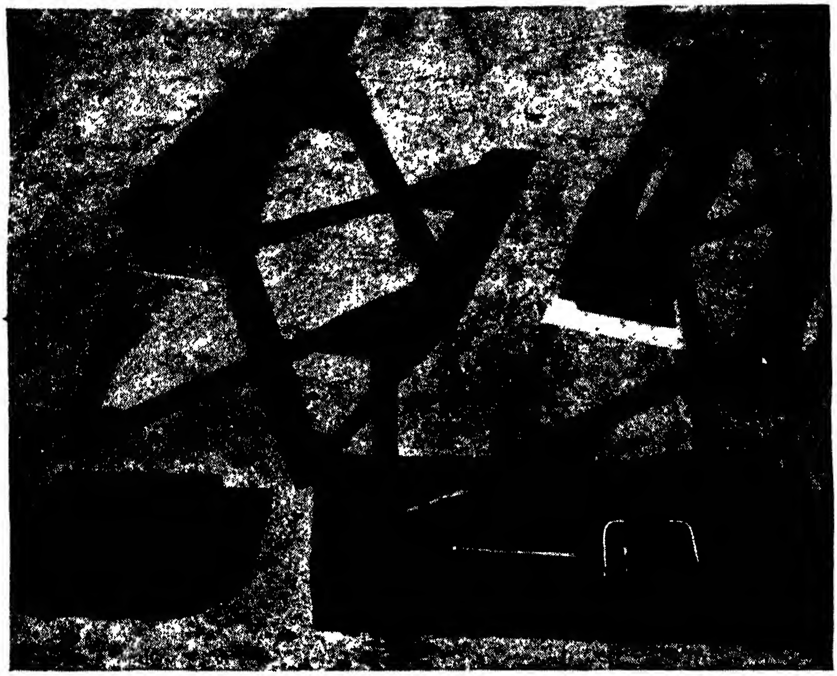


Fig. 1-9. Many useful pieces of shop equipment are easily made in the shop.

Fig. 1-10. A good type of wall tool cabinet. (University of Minnesota)

and dust and can be locked if desired. Plain wooden cabinets are easily constructed in the shop and fastened to the walls. Hooks, shelves, and racks can be arranged inside the cabinets, even on the inside of cabinet doors. Thus many tools can be stored in a small space. Larger tools, such as spades, shovels, hoes, axes, and large wrenches, can be hung on racks or hooks on the walls or stored in closets.

Marking places for tools It is a good plan to mark the outlines for tools stored in cabinets and for many of the tools hung on walls or tool boards. This can be done quickly and easily with a heavy black lead pencil or with crayons. It is better, however, to take a little more time and paint neat outlines or silhouettes of the tools (see Fig. 1-11). Such marking or silhouetting helps greatly in getting tools back to their proper places and keeping them from getting lost.

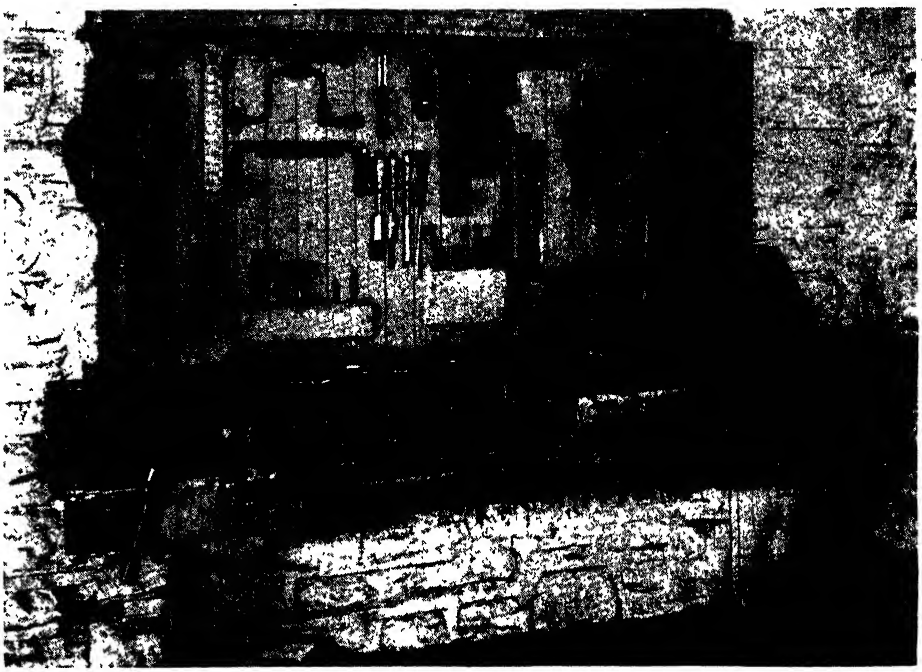


Fig. 1-11. A workbench with an open tool board above it. The painted silhouettes are a great help in getting tools returned to their places.

In arranging places for tools, keep in mind the protection of cutting tools, particularly keen-edged woodworking tools. Do not crowd them together or hang or place them in such a way that they might fall or be dislodged when adjacent tools are removed from the rack.

5. STORING SUPPLIES AND MATERIALS

Systematic and orderly storage of supplies and materials, as well as of tools, contributes a great deal to the value and usefulness of a shop. Keep supplies and materials where they can be easily and readily

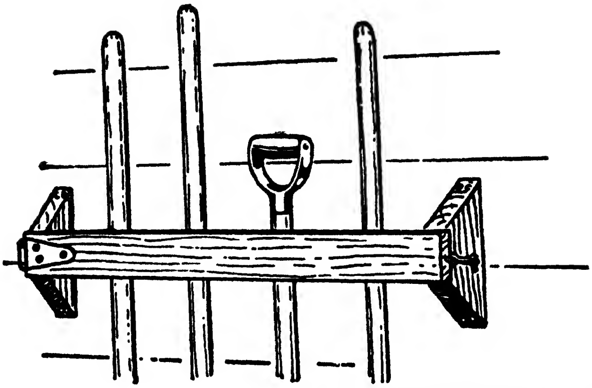


Fig. 1-12. A good way to keep tools like shovels, hoes, and forks from getting underfoot.

Fig. 1-13. A vertical steel rack makes an excellent place to store rods, bars, and pipes.

found, and do not allow them to clutter up the benches, work spaces, or floor.

Storing miscellaneous small supplies Small bins or drawer cabinets are ideal for storing nuts, bolts, screws, nails, and similar supplies. Bins for bolts are easily made in the shop. If small drawers are not available, screws may be kept in small glass jars, or left in their original paper-box packages and arranged in order on shelves. Well-marked containers placed on shelves also make a good system for storing small quantities of many miscellaneous supplies.

Storing lumber If wall space is available, small amounts of lumber may be stored on racks built along the walls of the shop. In many shops, overhead storage is practical for small quantities of lumber that may be needed only at infrequent intervals. In case of overhead storage, however, be sure to provide a convenient and safe ladder or stairs.

Only small amounts of lumber will generally need to be stored in the shop for long periods. Where considerable lumber storage is needed, provide space in some place other than the shop, such as the machinery building. Lumber stacked on the floor requires considerable space and handicaps work in the shop.

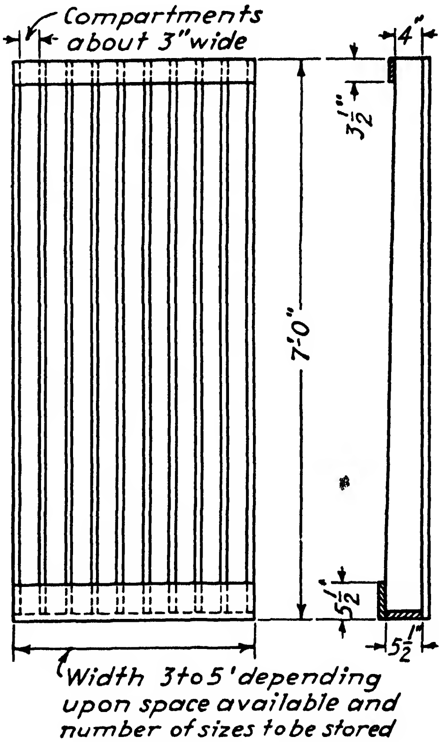


Fig. 1-14. Plans for a vertical steel rack.

Storing steel Steel rods and bars can usually best be stored by standing them on end. A rack with small compartments for keeping the various sizes separate is easily constructed (see Figs. 1-13 and 1-14). Short lengths as well as long ones are easily stored in such a rack. Furthermore, very little floor space is required for steel thus stored, and the rack is easily kept in order.

Planning desk and file space Every shop needs a place to keep catalogues, instruction books, repair-parts lists, notebooks, paper, and records or reminders relating to repair work, fuel, supplies, and the like. A small mouseproof cabinet, set of drawers, or desk will accommodate such papers.

6. PROVIDING FACILITIES FOR SERVICING TRACTORS AND MACHINERY

Facilities are needed somewhere about the farmstead for safely and conveniently refueling, lubricating, and adjusting tractors and machinery. Such a service center cannot be safely provided in the shop, but it should generally be located near it.

Storing fuel The National Fire Protection Association states that fuel in containers of 60 gal or less may be stored inside a building, provided it is used exclusively for storing flammable liquids and is

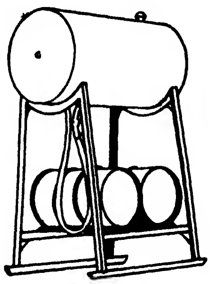


Fig. 1-15. An elevated fuel tank is preferred on many farms. If mounted on skids it can be moved to the fields or kept at the farmstead. A shady location is best.

located at least 40 ft from other buildings. It is usually most practical to store fuel for tractors and engines out of doors at least 40 ft from buildings, unless it is stored in underground tanks, in which case it may be as close as 16 ft to buildings. For a permanent installation an underground tank with fuel pump at least 16 ft from the shop is probably safest and most satisfactory.

On many farms the choice for fuel storage is an elevated tank. It should be located at least 40 ft from buildings. Put it where it is easily accessible to fuel trucks and to tractors and farm machines, and where it will not detract from the appearance of the farmstead. Locate the tank in a shady place or have a roof built over it.

Storing oils, grease, and lubricating equipment It is generally most convenient to keep oils, greases, and lubricating equipment, such as grease guns, funnels, and measures, near the fuel storage, so that

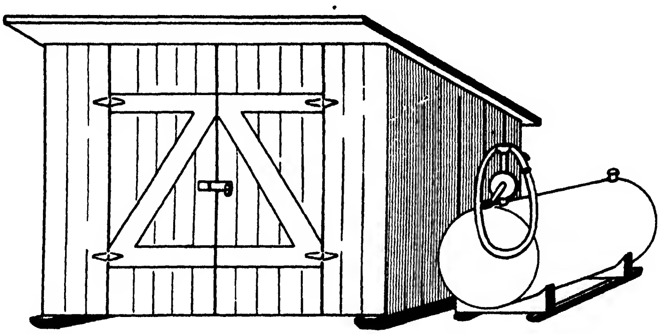


Fig. 1-16. A small building or a large box or cabinet is needed for storing lubricants and equipment like grease guns, measures, and funnels.

the servicing of tractors and machines can be done at one place. A large cabinet or box, or a small building on skids, located at the fuel-storage tank meets the needs on most farms.

7. PRACTICING SAFETY IN THE SHOP

Safety precautions in and around the shop are important to protect both the workers and the equipment and buildings from accident and injury. The following are a few of the more important safety precautions.

Practice good shop housekeeping Keep work spaces free from obstructions. Dispose of junk and rubbish promptly. Keep workbenches and tools clean and in good order. Wipe up spilled grease and oil promptly and keep floors clean and dry.

Protect yourself against injury Keep tools in good condition. Wear goggles when grinding. Keep guards on belts, pulleys, and gears. Place blocks under machines that are hoisted or jacked up before working under them. Be especially careful when using power saws and other equipment that might cause injury.

Guard against fumes Do not run an engine in a closed space unless the exhaust is piped to the outside. Avoid breathing fumes from welding, particularly those from galvanized iron.

Fig. 1-17. Safety precautions are important in and around the shop. Keep a fire extinguisher just inside the shop door.

Avoid fire hazards Keep only a small quantity of gasoline in the shop, and keep it in a safety can. Store flammable liquids in approved containers. Put oily rags in closed metal containers, and dispose of them at frequent intervals. Protect the walls near the stove, forge, or welder with asbestos-cement board or sheet metal.

Keep a fire extinguisher handy Hang a carbon dioxide or carbon tetrachloride hand-type extinguisher just inside the shop door. Also keep pails or boxes of dry sand in the shop to extinguish oil fires.

Keep a first-aid kit in the shop Use it even for apparently minor cuts and injuries.

Important points in planning, equipping, and using a farm workshop

1. A shop located in or attached to the machinery building is usually best. A shop combined with a garage is practical under some conditions, but a separate shop is seldom recommended.
2. A good location for the shop is on one side of a central service yard or court where it will be convenient to machines as they are taken to and from fields.
3. A floor space of about 14 by 20 ft is adequate for most shop needs if other nearby space is available for machines while being repaired.

4. Concrete makes an ideal floor for a farm shop.
5. Put windows on at least two sides of the shop—preferably three—to give good light and cross ventilation.
6. The shop needs two doors—an ordinary service door, and a larger door, at least 8 ft wide and 7 ft high (and preferably larger), for bringing in large machinery to be repaired.
7. Plan for generous use of electricity in the shop. Provide plenty of outlets for lights, and also for attaching electrically operated tools and appliances.
8. Install some kind of stove or heater to provide comfortable working conditions in winter.
9. The most practical way to equip a shop is first to clean and repair tools that are already about the place, and then to buy additional tools from time to time as they are needed and the expense can be justified.
10. Get a good set of basic hand tools first, and then add larger power tools or special equipment later as needed.
11. Place benches and the larger pieces of equipment along the sides or ends of the shop, leaving a large unobstructed space in the center for repair and construction work.
12. Make places for all tools. Use closed cabinets or open tool boards as preferred. Paint silhouettes to help in getting tools returned to their places.
13. Small bins or drawer cabinets are ideal for storing nuts, bolts, screws, and similar supplies. Well-marked containers arranged in order on shelves make good storage for miscellaneous small supplies.
14. Provide mouseproof desk or file space for instruction books, parts lists, memo books, and similar papers.
15. Provide a service center near the shop for refueling, lubricating, and adjusting tractors and machinery.
16. Practice safety in the shop. Keep it clean and orderly. Dispose of junk and rubbish promptly. Keep tools in good condition. Avoid fire hazards, but keep a fire extinguisher handy. Keep a first-aid kit in the shop.

2 SKETCHING AND DRAWING

1. Making Freehand Sketches
2. Making Pictorial Sketches and Drawings
3. Reading Working Drawings and Blueprints
4. Making Working Drawings
5. Lettering Sketches and Drawings
6. Making Floor Plans for Buildings
7. Making Out Bills of Materials
8. Writing Specifications to Accompany Drawings

A WORKING knowledge of sketching and drawing is a most valuable asset to anyone who deals with mechanical equipment. It enables him not only to read and interpret plans, drawings, and blueprints made by others, but also to clarify and transmit his own ideas regarding changes, repairs, or new construction work. The modern farmer deals more and more with mechanical equipment, and he particularly needs some knowledge and skill in making and reading sketches and drawings. Farm papers, periodicals, books, and bulletins contain a wealth of new and up-to-date information, much of which is in the form of diagrams and drawings. The improvements and repairs on machinery and buildings which a farmer can make or have made often depend upon his skill in reading or making sketches and drawings.

1. MAKING FREEHAND SKETCHES

For many jobs around the farm, the home, or the farm shop, simple rough sketches will do practically as well as finished drawings. Every

farmer should learn how to make sketches of top, side, and end views of an object and also pictorial sketches, regardless of whether he does his own construction work or has it done by others.

Sketching lines Use a soft, well-sharpened pencil, and hold it lightly and not too close to the point. Using short, rapid strokes, make a series of short, light lines joined together with a little overlapping. Make vertical lines from the top downward, and mainly with a finger movement (see Fig. 2-1). Make horizontal lines from left to right, and mainly with a side-sweeping wrist motion (see Fig. 2-2).

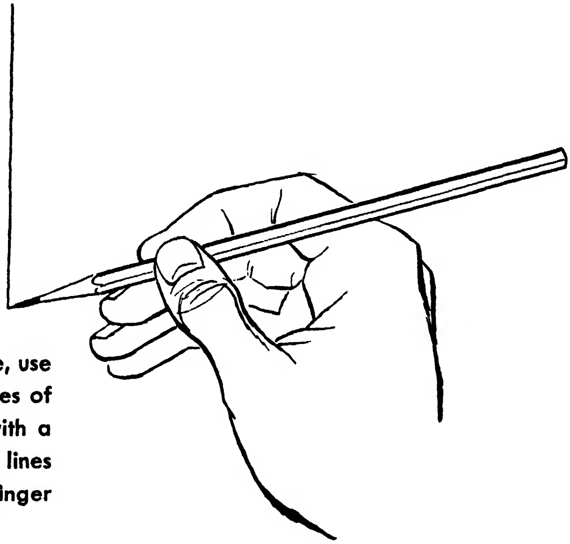


Fig. 2-1. In sketching a vertical line, use short, rapid strokes, making a series of short, light lines joined together with a little overlapping. Sketch vertical lines from the top downward with a finger motion.

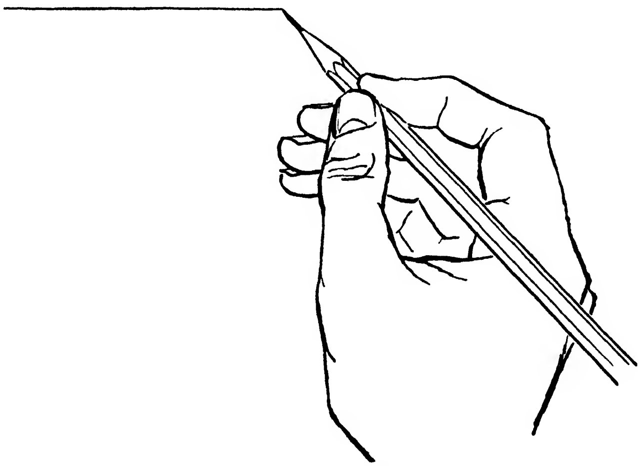


Fig. 2-2. Sketch horizontal lines with a side-sweeping wrist motion.

The principles of sketching and drawing may be better understood by imagining that the object to be drawn is placed in a glass box (see Fig. 2-3). The top view is what would be seen by looking straight down through the top of the glass box directly from above. The front view is what would be seen when the object is viewed directly from the front. Likewise, a right or left end (or side) view is what would be seen from the right or left end.

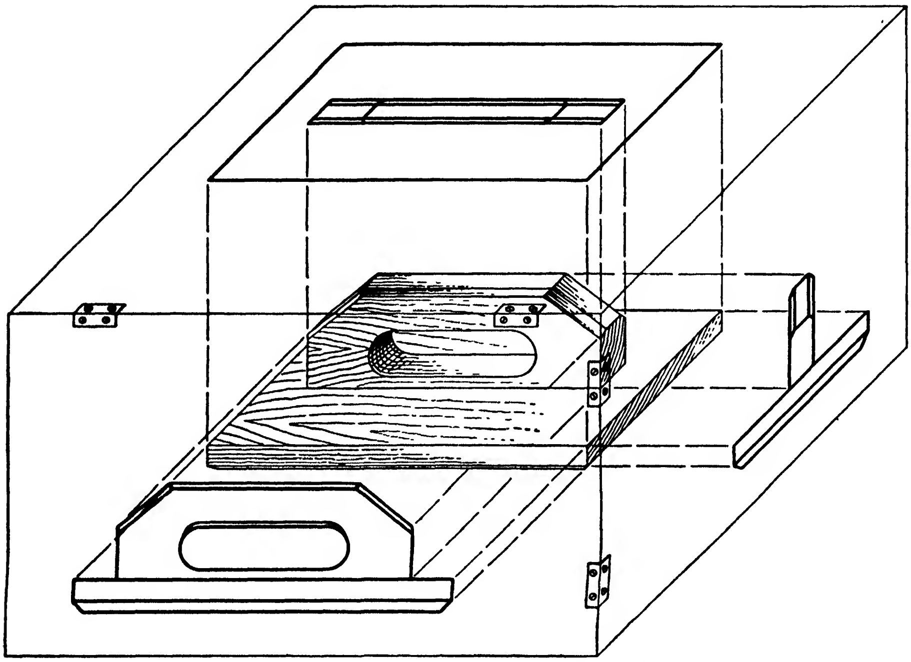


Fig. 2-3. A wood float in a glass box with top, side, and end views projected onto the top, side, and end of the box.

The proper position of the various views on a sketch or drawing may be determined by imagining that the top and the ends of this glass box are hinged and swung out as shown in Fig. 2-4. The top view occupies the upper left part of the drawing, the front or side view is directly below, and the right end view is directly to the right of the side view.

Choosing the views Several different views of an object may be shown, but usually only two or three are necessary. Select those views which will best and most easily show the shape and size of the various

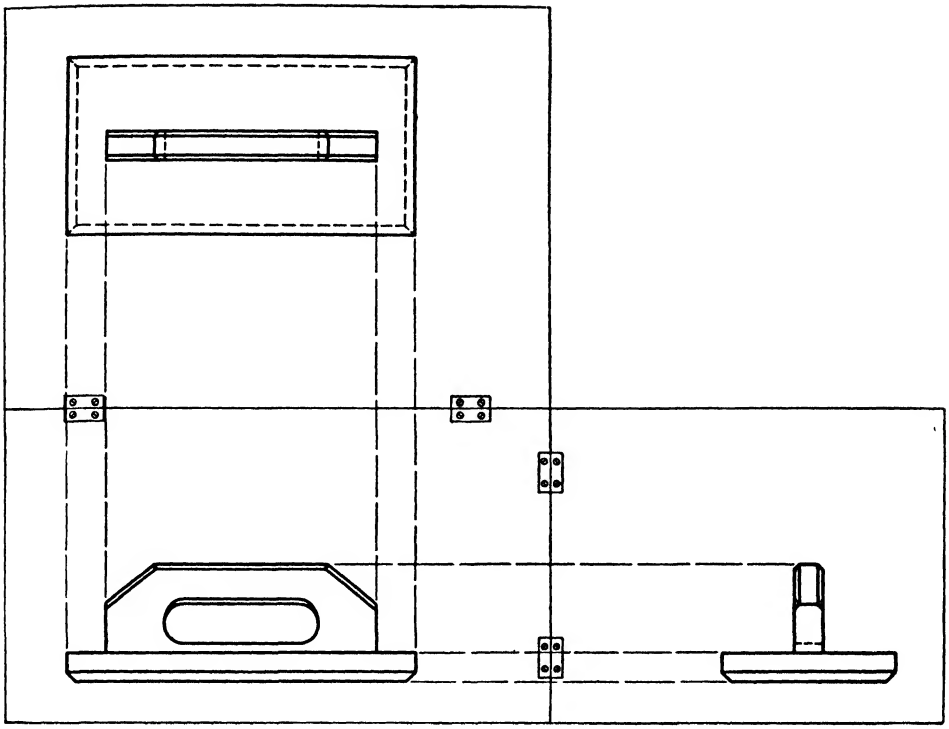


Fig. 2-4. The glass box opened to show positions of top, side, and end views.

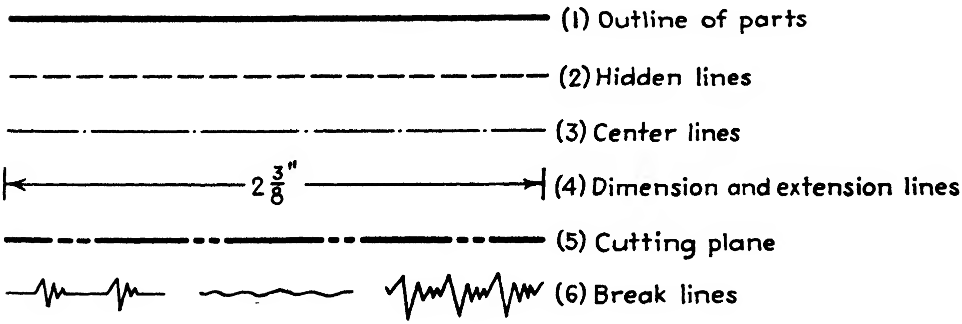


Fig. 2-5. Alphabet of principal lines used in drawing and sketching.

parts of the object. Usually a top view, a side view, and one end view are sufficient, and in many cases only a side view and an end view are needed.

As the sketching proceeds, use care to make the various lines of suitable length, so as to keep the different parts of the drawing in proper proportion. Make the outlines of the main views first, then add the minor lines, and finally the dimensions and notes.

Using the right kind of lines; alphabet of lines Use normal full-weight lines to show the main outlines of an object which are visible in any particular view. Use dashed lines, called *dotted* or *broken lines,* to show those parts which are not visible. The various kinds of lines commonly used in sketching and drawing are shown in Fig. 2-5. Since each kind of line has a definite significance, it should always be used for its particular purpose.

Dimensioning sketches and drawings A sketch or drawing should show all measurements or dimensions of an object that are essential for its construction. Some of the more important rules and practices of dimensioning are stated below:

1. Make light lines, called *extension lines,* extending out from edges or other parts to be dimensioned. Make these lines almost but not quite touch the main lines of the drawing.

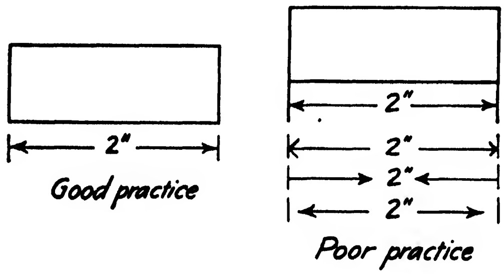


Fig. 2-6. Examples of good and poor practice in dimensioning.

2. Draw light dimension lines, with arrowheads at the ends, between the extension lines.
3. Make neat, sharp arrowheads, and make the points come *exactly* to the extension lines (see Fig. 2-6).
4. Leave space in the middle of the dimension lines for the insertion of figures. [On some drawings, particularly on building plans, it is common practice to make dimension lines solid without space for figures, and to place the figures beside the lines somewhere near the middle (see Fig. 10-4).]
5. Place figures so that horizontal and sloping dimensions read from left to right, and vertical dimensions read from bottom to top. (Some prefer to place all figures so as to read from left to right, even in vertical dimensions. Either practice is all right, but do not use both practices on the same drawing.)
6. Place dimensions outside the views so far as possible. Place dimen-

sions on a view only if this will make the drawing simpler and easier to read (see Fig. 2-7).

7. Dimensions which apply to two views of an object should be placed between the views, unless there is a special reason for placing them elsewhere (see Fig. 2-8).

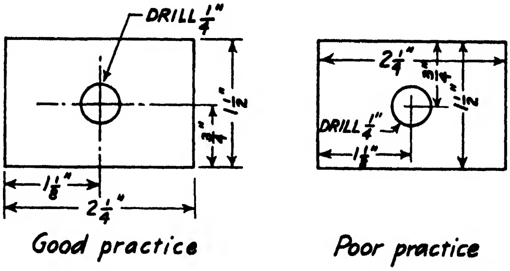


Fig. 2-7. Do not place dimensions on a view unless it would make the drawing clearer.

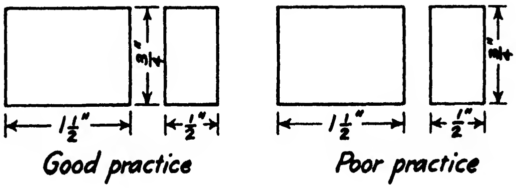


Fig. 2-8. Dimensions which apply to two views should be placed between them.

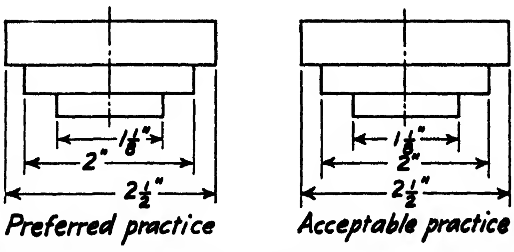


Fig. 2-9. Stagger the figures in parallel dimensions where it will make them easier to read.

8. Place the figures about halfway between the arrowheads, except in the case of several parallel dimensions.
9. Where you have several parallel dimensions, stagger the figures (do not place them all halfway between the arrowheads) in order to make them easier to read (see Fig. 2-9).
10. Leave at least ¼ inch of space between parallel dimension lines, or between a dimension line and a main line of the drawing.
11. Indicate the size of a circle by its diameter, not its radius (see Fig. 2-10).

12. Dimension an arc (part of a circle) by giving its radius, followed by an *R* (see Fig. 2-10).

13. Show the location of a hole or a circle by dimensioning from its center lines (see Fig. 2-7).

14. Brief notes may be used, with light leader lines and arrowheads leading to the parts of the drawing to which the notes apply (see Fig. 2-11).

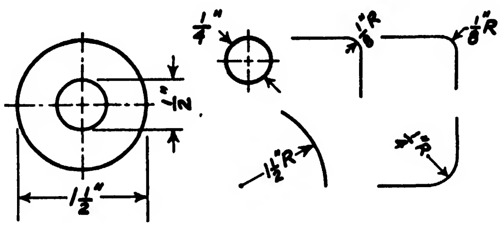


Fig. 2-10. Examples of dimensioning holes, circles, and arcs.

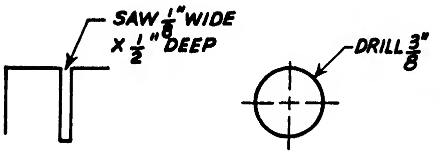


Fig. 2-11. Brief notes with leaders are often used in dimensioning drawings.

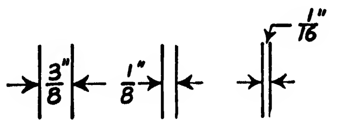


Fig. 2-12. Methods of showing dimensions in limited space.

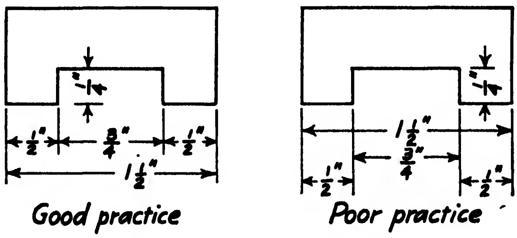


Fig. 2-13. Show a series of dimensions in a continuous line. Also indicate the over-all dimension and place it on the outside.

15. Do not crowd figures. If space is limited, use one of the methods shown in Fig. 2-12.

16. Where possible, show a series of dimensions in a continuous line (see Fig. 2-13), and always give the over-all dimension as well as the component or smaller dimensions which make up the total. Place the over-all dimension on the outside.

Making sectional views Sectional views, often called simply *sections,* are used to show the shape of complicated parts, particularly the interior of parts, and objects composed of several pieces. Dotted lines can be used to show the shape or construction of such pieces, but they sometimes unduly complicate a drawing and make it difficult to read.

To make a sectional view, imagine that the object is cut in two and the front part removed (see Fig. 2-14). Then make a view of the exposed end, and show the solid portions cut by the sectioning plane by crosshatching, that is, with lightweight diagonal lines (see Fig. 2-15). The exact position of the section is indicated on one of the main views by means of a line made up of a series of long dashes separated by two short dashes (see Fig. 2-15).

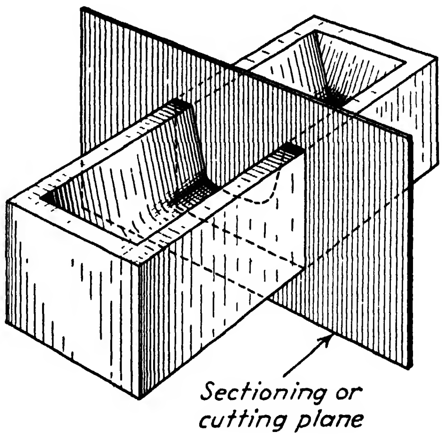


Fig. 2-14. An imaginary sectioning or cutting plane making a cross section of a concrete trough.

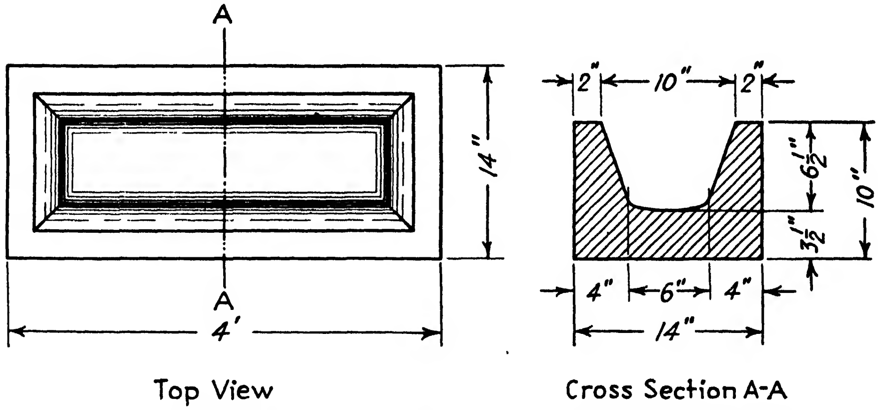


Fig. 2-15. Top view and cross section of trough shown in Fig. 2-14.

Instead of crosshatching, other symbols are commonly used for materials like concrete, earth, and wood (see Fig. 2-16).

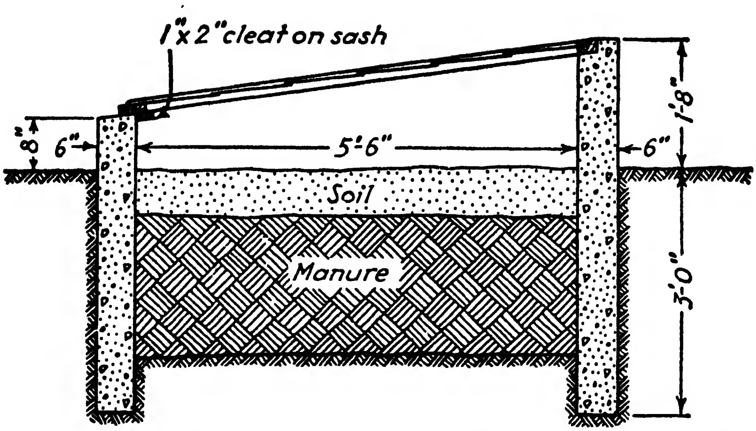


Fig. 2-16. A cross-section view of a hotbed. Note the methods of showing sections of different materials.

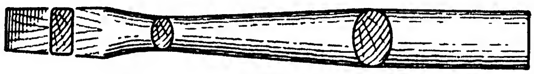


Fig. 2-17. Revolved sections to show the shape of the hammer handle at different places.

A *revolved section* is a small sectional view shown on one of the main views. Such a sectional view shows the shape of a cross section at that particular place (see Fig. 2-17).

2. MAKING PICTORIAL SKETCHES AND DRAWINGS

The ability to make a pictorial view either freehand or with instruments is of great value in conveying a general idea of the shape or appearance of an object. Pictorial drawings show three sides or faces of an object in one view, much as a picture would. In farm shopwork, a pictorial sketch is often adequate in itself without side, top, or end views. A pictorial sketch or drawing is often valuable as a supplement to a drawing composed of various views, particularly when the drawing is to be read or interpreted by those not altogether familiar with the principles of drawing. Complete, detailed dimensions are difficult or impossible to show on pictorial drawings. Such drawings, therefore, are not generally used alone to show a complicated object, particularly if it must be made to exact dimensions.

Pictorial sketches and drawings may be grouped into three main classes: isometric, oblique, and perspective.

Making isometric sketches and drawings These are made about three lines or axes, one vertical, and two at 30 deg with the horizontal (see Fig. 2-18). Such a drawing can show a top, a side, and an end view of an object. The dimensions of only the main parts of an object can be indicated on an isometric drawing.

Making oblique sketches and drawings These are made about three axes, in much the same manner as isometric sketches and draw-

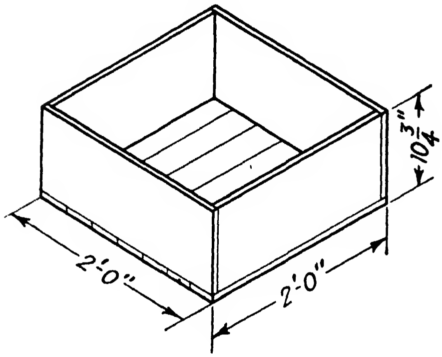


Fig. 2-18. An isometric drawing.

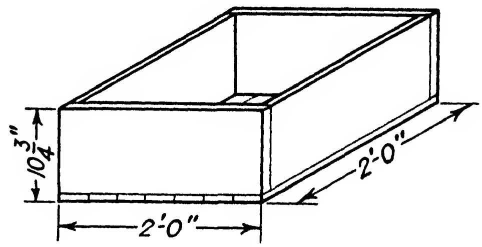


Fig. 2-19. An oblique drawing.

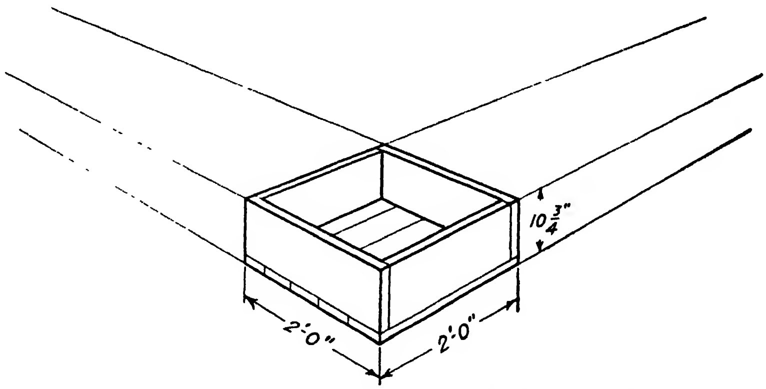


Fig. 2-20. A simplified type of perspective drawing.

ings, except that one of the axes is always horizontal, one vertical, and the third at any convenient angle (see Fig. 2-19). One view is thus the same as an ordinary front view. If one side of an object contains curved or irregular lines, this side should be selected for the front view.

Making perspective sketches and drawings These show objects just as they appear to the eye. They have a more pleasing appearance than

isometric or oblique drawings, but are more difficult to make. A simplified type of perspective drawings, however, may be made similar to isometric drawings. Such a drawing is made like an isometric drawing, except that the lines at an angle to the horizontal are made to converge toward vanishing points, instead of being made parallel (see Fig. 2-20).

3. READING WORKING DRAWINGS AND BLUEPRINTS

Skill in reading working drawings and blueprints comes with practice. Drawing is a language of its own. In order to read drawings and to understand them, one must know something of the principles of drawing as outlined in this chapter. As in most shop work, it is advisable to become well grounded in the principles by thoughtful practice. Then the application and use of the principles become easy.

In reading a drawing, first look at its title or nameplate, to see what it represents or what the purpose of it is. Then look at the various views and identify them. By so doing, you will learn the general shape of the object. By comparing the various views and studying them in relation to each other, one can picture in his mind's eye the shape of the object. For example, on the front view a hole on the front of an object appears exactly the same as a projection. A glance at the top or side view quickly reveals whether it is a hole or a projection.

After learning the general shape of the object, proceed to find out details and dimensions. First note the over-all size or dimensions and then the dimensions of the smaller parts or subdivisions of the main object. If detail or separate drawings of certain parts are provided, study these to determine the shape and size of the various parts.

4. MAKING WORKING DRAWINGS

Drawings are made in much the same manner as outlined in the preceding pages for making sketches. The main difference is that lines are made straight with the use of a T square and triangles, instead of freehand. The lines are also measured and made exactly proportional in length to the parts of the object they represent. It is usually not practical to make the drawing the same size as the object.

Drawing to scale Making a drawing proportional in size to the object is known as drawing to scale. The scale of a drawing is com-

monly indicated by such terms as ¼ in. = 1 in., ½ in. = 1 ft, or ⅛ in. = 1 ft.

An architect's scale (see Fig. 2-21) is commonly used for measuring lines in making and reading building plans. Each main division on such

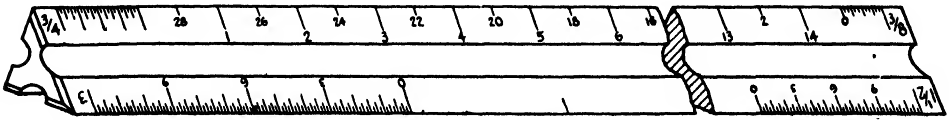


Fig. 2-21. An architect's scale.

a scale represents 1 ft, and the end divisions are subdivided to represent inches, half-inches, etc. Such a scale, while desirable and convenient, is certainly not necessary for making simple drawings. An ordinary ruler is particularly easy to use when some common division, such as ⅛, ¼, or ½ in., is used to represent 1 in. or 1 ft.

Probably the fastest and easiest way to make simple drawings and sketches to scale, however, is to use cross-ruled paper, with 4, 8, or 12 divisions to the inch. Lines can then be drawn to scale by simply counting the appropriate number of divisions on the paper.

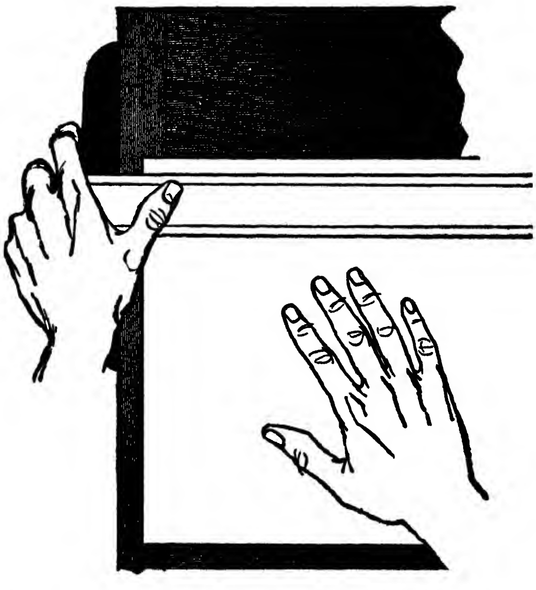


Fig. 2-22. Aligning the paper with the edges of the drawing board.

Laying out and developing the views To start a drawing, first fasten the paper to the drawing board with thumbtacks or tape, using the T square to align the paper with the edges of the board (see Fig. 2-22). Next, choose a suitable scale and locate and mark off the spaces for the various views. Lay out the main lines of the drawing, and then add the minor ones. Develop all views along together, projecting from one view to the other with the T square and triangles. Add dimension lines and notes last.

Always use a *well-sharpened* pencil so that the lines will be light and sharp and located accurately. Rule vertical lines from the bottom up and horizontal lines from left to right. Lines at various angles can be made with the T square and triangles. Hold the head of the T square firmly against the edge of the drawing board, and hold the triangles firmly against the T square.

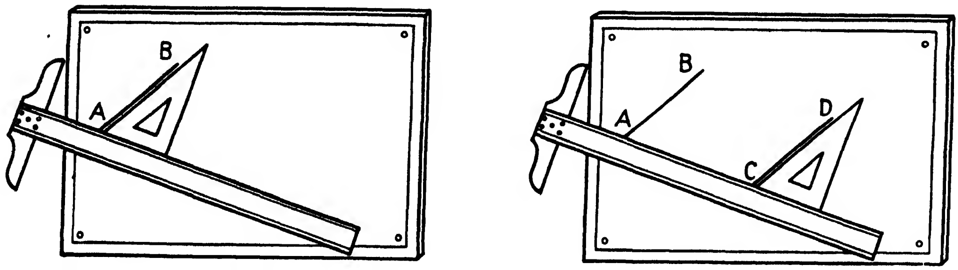


Fig. 2-23. To draw a line parallel to a given line: adjust the T square and triangle to align with the given line *AB*; then slide the triangle along the T square to the desired position and draw the required line *CD*.

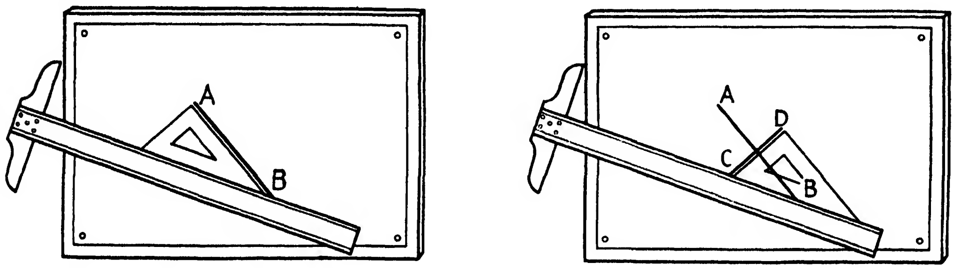


Fig. 2-24. To draw a line perpendicular to a given line: adjust the T square and the triangle to align with the line *AB*, with the hypotenuse of the triangle against the T square. Then slide the triangle along into position and draw the required line *CD*.

To make a line parallel to a given line, move the T square about so that when the base of the triangle is against the T square, one side of the triangle coincides with the line. Then slide the triangle along into position for the new line, holding the T square firmly in place (see Fig. 2-23).

To make a line perpendicular to a given line, place the triangle with the *hypotenuse* against the T square (see Fig. 2-24) and shift the T square about until one side of the triangle coincides with the given line. Then slide the triangle along the T square and draw the perpendicular.

5. LETTERING SKETCHES AND DRAWINGS

Titles and notes on drawings are lettered (printed)—not written in script. Neat lettering adds materially to the general appearance of a drawing or sketch, as well as making it more legible and easily and quickly read.

Neat rapid lettering comes, first, from careful attention to approved ways of making each letter, and then from patient practice. Care

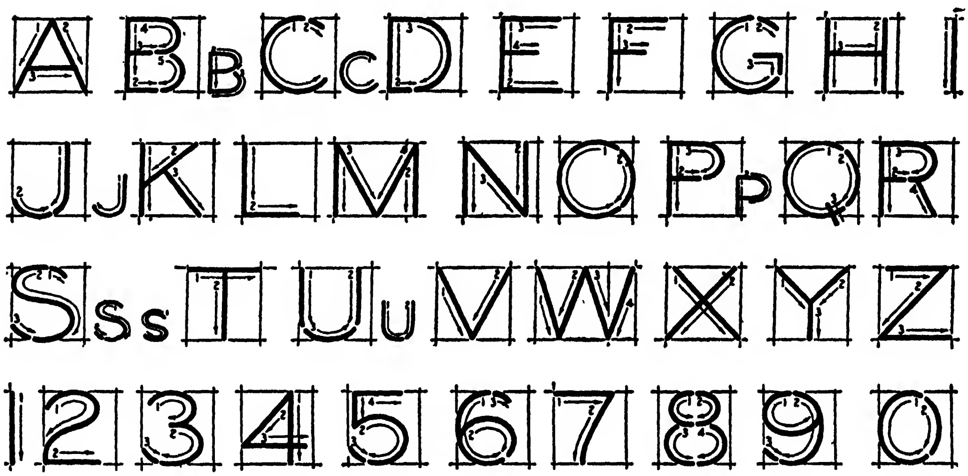


Fig. 2-25. The vertical capital style of lettering is probably most used. It is recommended as the style easiest to learn.

should also be given to the spacing of the words and to the spacing of letters within words. Use light guide lines for lettering drawings. This practice is used by even skilled and rapid draftsmen.

Various styles of lettering are used on drawings and plans. Vertical capital letters (see Fig. 2-25) are probably most commonly used, and are recommended as the style easiest to learn. It is the mark of poor or careless workmanship to use capital letters and small (lower-case) letters indiscriminately, or to use various styles of lettering on the same drawing. Figure 2-25 also shows the order of strokes in making various letters and figures.

6. MAKING FLOOR PLANS FOR BUILDINGS

Before a floor plan for a building such as a barn can be made, some preliminary estimating or figuring will need to be done. If a building

is to be remodeled, the main dimensions will already be determined, and the problem will be to make the best arrangement of bins, stalls, alleys, and other principal parts. If a new building is being planned, the floor arrangement may be designed from units; when allowance has been made for a certain number of stalls of a given size, a certain number of bins, etc., the required over-all, or outside, dimensions can be determined. Many farm buildings are commonly made in certain more or less standard widths. Reference to standard plans and bulletins will usually suggest suitable widths, as well as other principal dimensions. It is usually easier and more practical to make modifications in a common or standard plan than to make an altogether new design.

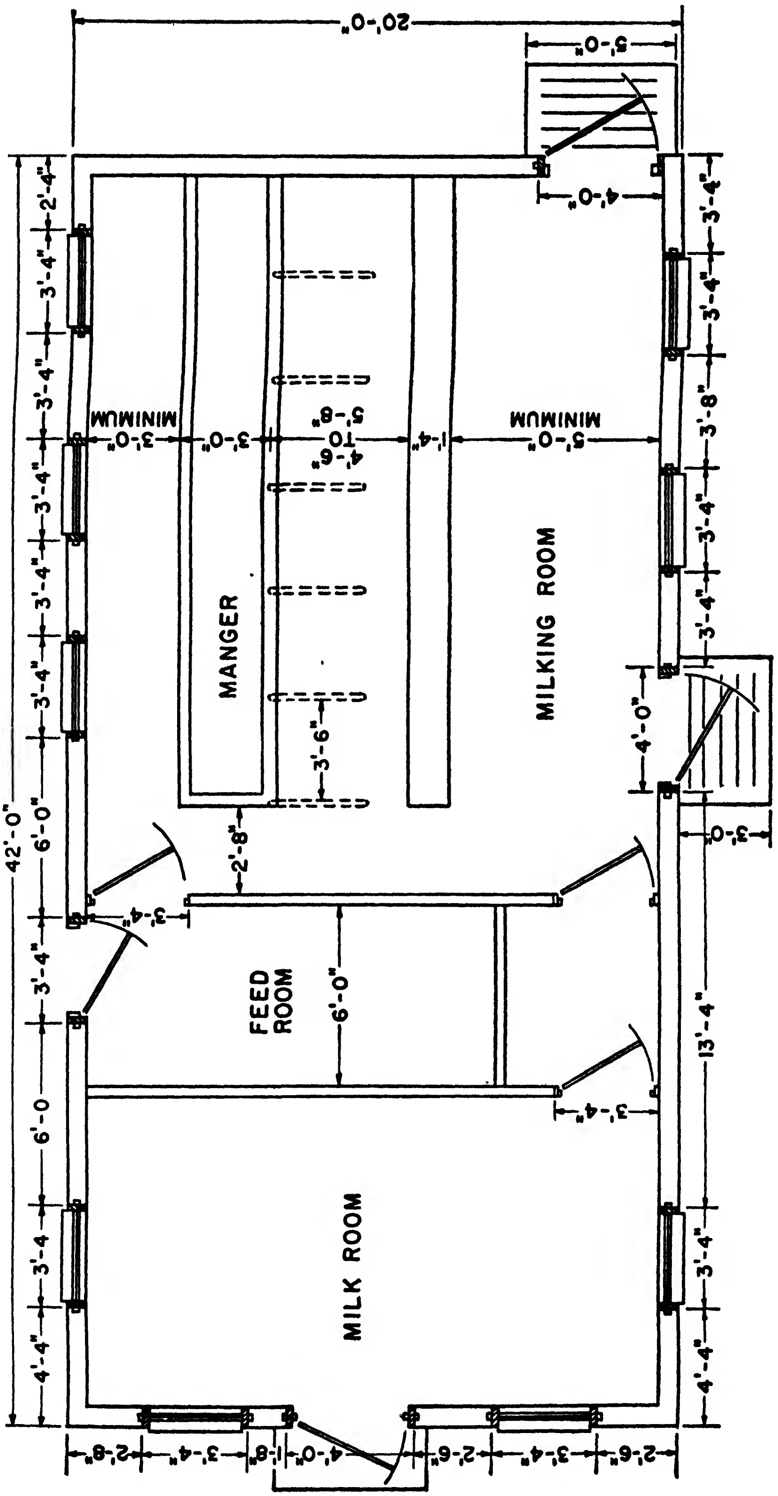
Once the main dimensions are determined, lay off the outside lines of the floor plan, using a suitable scale. (Cross-ruled paper, with rulings of four, eight, or twelve lines to the inch, is very good for making floor plans.) Next, lay off the lines showing the inside of the walls. Then locate doors, windows, inside partition walls, stall partitions, feed alleys, etc., using standard or other suitable dimensions for these various units. Finally, add dimensions and notes and smaller details as may be desired. Figure 2-26 shows a floor plan for a combination milk room and milking barn, sometimes called a "milking parlor."

7. MAKING OUT BILLS OF MATERIALS

Plans for buildings and for larger appliances are usually accompanied by lists of materials required for their construction. When such lists or bills of materials do not accompany the plans, then they should be made before construction is started.

A bill of materials is usually in tabular form and indicates just what part of the building or project the various pieces are to be used for, as well as the number of pieces and the size, length, kind, etc. In the case of a larger building or project, the bill of materials should give a summarized list of the total requirements of all pieces of the same kind and size. Descriptions of materials should be exact and complete, so that they can be easily bought or ordered from the usual sources of supply.

Although the making of bills of materials for any except the simpler and smaller buildings is beyond the scope of a course in beginning shopwork, every student should include lists of materials with the job plans for the jobs he expects to do in the shop.



FLOOR PLAN
SCALE: 1/4"=1'-0"

Fig. 2-26. A floor plan for a combination milk room and milking barn.

Figuring board measure Since lumber is commonly sold by the *board foot,* or foot, *board measure,* a bill of materials usually indicates the number of board feet of various kinds of lumber required. A board foot is the amount of lumber in a piece 1 in. thick, 1 ft wide, and 1 ft long. In other words, a board foot is equivalent to $\frac{1}{12}$ cu ft. The number of board feet in one or more pieces of lumber may be determined, therefore, by first finding the number of cubic feet contained in the lumber and then multiplying by 12. This method may at first seem to be tedious, but in practice it is easy to use. Simply apply the following simplified formula:

$$\text{board feet} = \frac{\text{number of pieces} \times \text{inches thick} \times \text{inches wide} \times \text{feet long}}{12}$$

Cancellation will nearly always simplify the figuring so that it may be done without tedious multiplication and division. For example, to find the number of board feet in three 2 by 4s, 10 ft long

$$\text{board feet} = \frac{\cancel{3} \times 2 \times \cancel{4} \times 10}{\cancel{12}} = 20$$

Lumber less than 1 in. thick is commonly measured in square feet instead of board feet.

Mill-surfaced lumber is never full width or full thickness, owing to the waste removed when the boards are surfaced or planed. Board measure, however, is always figured as if the boards were full width and thickness. For example, a 2 by 4 actually measures about $1\frac{5}{8}$ by $3\frac{5}{8}$ in., but it is always figured as a full 2 by 4 in.

Determining amount of lumber to cover a surface Since boards are not full width, they will not completely cover the area indicated by their nominal size. In bills of materials, therefore, a certain amount over and above the indicated number of board feet must be allowed. A general rule is to add about one-twelfth when using 1 by 12 boards, about one-tenth for 1 by 10s, about one-eighth for 1 by 8s, etc. For tongue-and-groove or matched lumber like shiplap, flooring, siding, and ceiling, an amount varying from one-eighth to one-third or more must be added, depending upon the width of the boards and the amount of lapping in the grooves.

8. WRITING SPECIFICATIONS TO ACCOMPANY DRAWINGS

When a building or a large piece of equipment is to be constructed, remodeled, or repaired, it is customary to write a set of specifications to amplify and supplement the drawings. Specifications are essentially a set of statements of kinds and grades of materials to be used, methods of construction, qualities of workmanship, finish, etc. The specifications together with the drawings should leave no doubt as to the materials to be used or how any part of the work is to be done. The test of any set of specifications and drawings is whether or not they answer questions that arise as the work proceeds. In the case of large buildings, the specifications may be long and involved, and they should be written or checked by an experienced builder.

JOBS AND PROJECTS

1. Sketch top, side, and end views of a workbench in the shop. Indicate the principal dimensions.

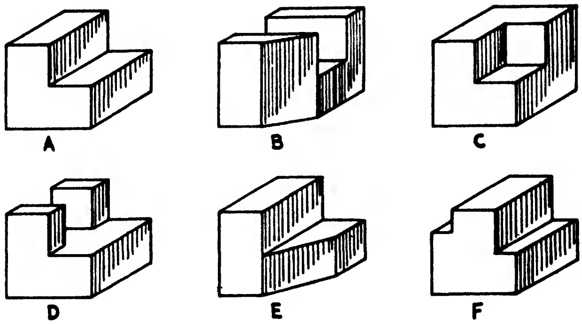
2. Sketch top, side, and end views of one or two other appliances or pieces of equipment in the shop, showing the main dimensions. Use the right kind of lines to show hidden parts, extension lines, dimension lines, etc.

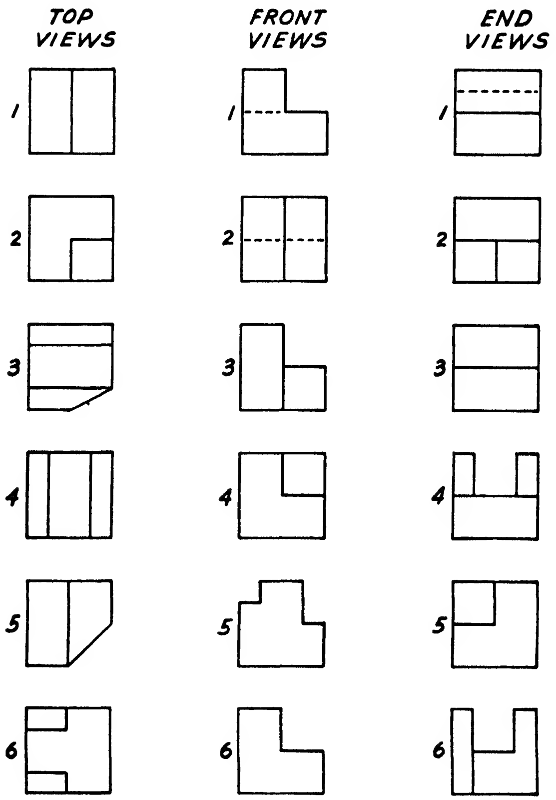
3. Sketch a sectional view of a nail or tool box that may be available in the shop.

4. Sketch the floor plan of some small farm building (shop, garage, machine shed, poultry house, etc.) on your home farm or some farm in your community.

   Use cross-ruled paper and sketch the floor plan to scale, using an appropriate scale, such as one division equals 1 ft or two divisions equal 1 ft. Show the location and the size of doors, windows, and permanently placed equipment.

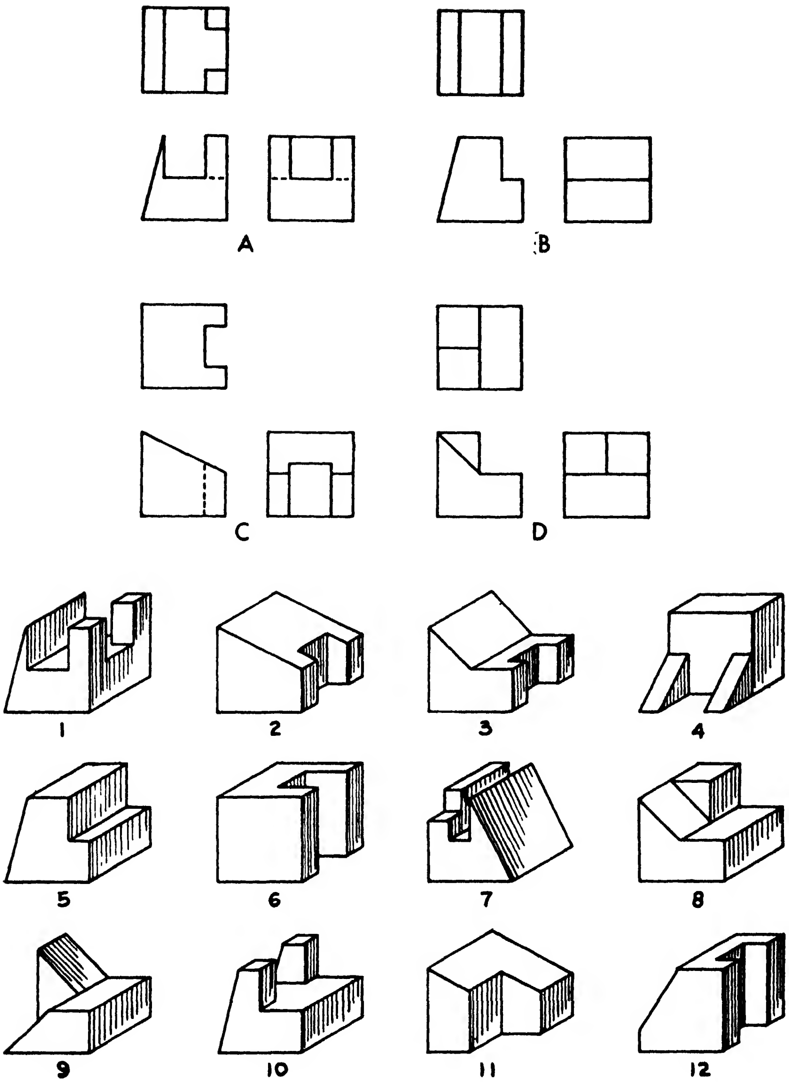
5. On cross-ruled paper, sketch the floor plan for a combination farm workshop and machine shed which you believe would be practical for your home farm or some other farm in your community.





	A	B	C	D	E	F
Top	1					
Front	6					
End	3					

6. Study the drawings above and select the proper top, front, and end view for each block. Indicate your selections by filling in the table below the drawings. (The first column of the table, for block *A,* is already filled in.)



7. Study the four sets of drawings at the top of this page and determine which block each set represents.

8. Design and make dimensioned sketches or drawings of some small shop or farm appliances (such as workbench, sawhorses, poultry feeder, tool cabinet) you would like to make in the shop.

3 WOODWORK AND FARM CARPENTRY

1. Selecting Kinds and Grades of Lumber for a Job
2. Measuring and Marking Wood
3. Sawing Wood with Handsaws
4. Planing and Smoothing Wood
5. Cutting with Wood Chisels
6. Boring and Drilling Holes in Wood
7. Fastening Wood
8. Shaping Curved and Irregular Surfaces
9. Cutting Common Rafters
10. Building Stairs and Steps
11. Laying Out and Erecting a Small Building

THERE will always be need for the farmer to make repairs and construct appliances involving the use of wood. It is easy to become reasonably proficient in the use of woods and woodworking tools, because woodworking, like most other kinds of mechanical work, is based on a comparatively few fundamental tool processes or operations, such as measuring, sawing, and planing. Once these processes are mastered, one is well on his way toward becoming a proficient woodworker.

1. SELECTING KINDS AND GRADES OF LUMBER FOR A JOB

Kinds and grades of lumber differ in such properties as strength, stiffness, hardness, toughness, freedom from warping, ease of working,

nail-holding power, wear resistance, decay resistance, paint-holding power, and appearance. In selecting lumber for a particular job, give consideration to the requirements of the job and to the properties of the lumber available, as well as costs. Often the practice or custom in the locality is a good guide to the best kind and grade of lumber to use. Sometimes lumber sawed from locally grown trees is more practical, and sometimes lumber shipped from a distance and sold through local lumberyards is better.

Lumber is classified technically into two general classes: softwoods, or lumber cut from needle-leaf evergreen trees, such as pine, fir, and cypress; and hardwoods, or lumber cut from broadleaf trees which shed their leaves, such as oak, hickory, and maple. Softwoods are in more general use for building construction and hardwoods for factory work. Southern yellow pine and Douglas fir are most widely used for construction work. Other lumber, such as white pine, cypress, and redwood, is used where it is available. Oak is the most commonly used hardwood. Hardwoods are generally better for work like tool and implement handles, floors, and furniture.

Softwood lumber is classified into various grades on the basis of the size, kind, and number of defects present. There are two general classifications: (1) select lumber and (2) common lumber. Select lumber is suitable for finishing or painting; common lumber has certain defects which detract from its appearance, but is suitable for general-utility and construction purposes. Select lumber is classified into two general classes, those suitable for natural finishes and those suitable for painting. Common lumber is likewise classified into two general classes, those which can be used without waste and those which require some cutting and waste. The various grades and subgrades are indicated in Table 3-1. The two highest grades of select lumber, A and B, are often sold together and designated as "B and better."

The grade classification of hardwoods is based upon the amount of clear usable lumber in a piece, rather than the size or number of defects present. "Clear" lumber has at least one side or face without defects. The other face must be sound, that is, free from heart center, shake (separation or cracks along the annular rings), rot, or other defects which would impair strength. The higher grades yield higher percentages of clear-face cuttings from the rough boards, and cuttings of larger size.

The highest grade of hardwood lumber is called *Firsts* and the second

TABLE 3-1. Grades of Softwood Lumber*

Total products of a typical log arranged in series according to quality as determined by appearance	Select (lumber of good appearance and finishing)	Suitable for natural finishes	Grade A (practically free from defects)
			Grade B (allows a few small defects or blemishes)
		Suitable for paint finishes	Grade C (allows a limited number of small defects or blemishes that can be covered with paint)
			Grade D (allows any number of defects or blemishes which do not detract from the appearance or the finish, especially when painted)
	Common (lumber containing defects or blemishes which detract from the appearance of the finish but suitable for general-utility and construction purposes)	Lumber suitable for use without waste	No. 1 Common (sound and tight-knotted stock; size of defects and blemishes limited; may be considered watertight lumber)
			No. 2 Common (allows large and coarse defects; may be considered graintight lumber)
		Lumber permitting waste	No. 3 Common (allows larger and coarser defects than No. 2 and occasional knotholes)
			No. 4 Common (low-quality lumber admitting the coarsest defects, such as decay and holes)
			No. 5 Common (must hold together under ordinary handling)

*From US Department of Agriculture Circular No. 64, How Lumber Is Graded.

grade *Seconds.* These two grades are generally sold together and designated as FAS (Firsts and Seconds). The third grade is called *Selects,* and the lower grades, *No. 1 Common, No. 2 Common, Sound Wormy, No. 3A Common,* and *No. 3B Common.*

2. MEASURING AND MARKING WOOD

Accurate measuring and marking are the first requirements for success in shopwork. Common measuring tools used in woodwork are the 2-ft folding rule, the zigzag-type folding rule, the extension folding rule, the push-pull pocket tape, the combination square, and the carpenter's steel square. The squares are also used for squaring as well as for measuring.

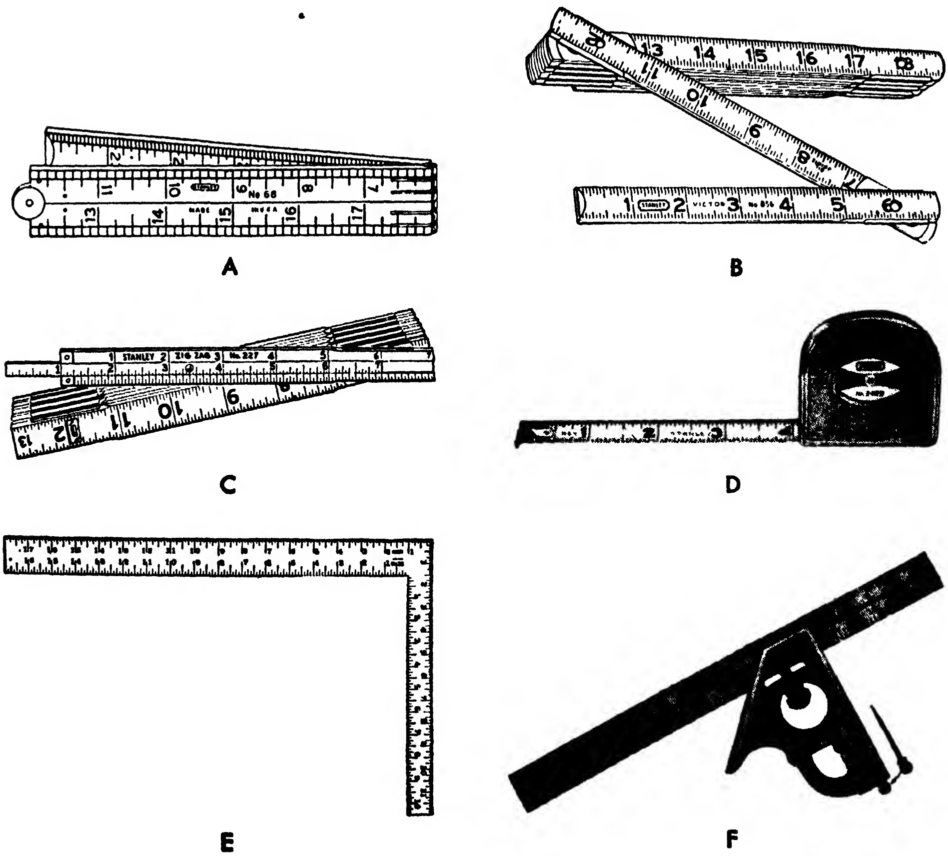


Fig. 3-1. Common measuring and marking tools used in woodwork. *A,* 2-ft. folding rule; *B,* zigzag folding rule; *C,* extension folding rule; *D,* push-pull pocket tape; *E,* carpenter's steel square; *F,* combination square. (Stanley Tools)

Reading a rule The graduation lines on a rule are varied in length to facilitate quick and accurate reading. The 1-in. lines are longest, the $\frac{1}{2}$-in. lines a little shorter, the $\frac{1}{4}$-in. lines still shorter, etc. (see Fig. 3-2). The smallest division on most rules used in woodworking is $\frac{1}{16}$ in.

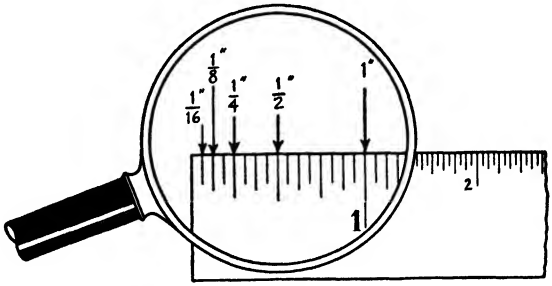


Fig. 3-2. The graduation lines on a rule are varied in length to facilitate reading.

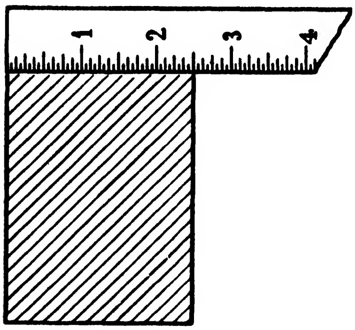


Fig. 3-3. Measuring with a rule.

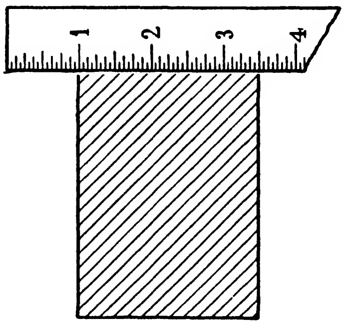


Fig. 3-4. A common method of measuring with a rule when the end is worn. Place the 1-in. mark even with one edge of the work and read the rule at the other edge. The true measurement is then the reading minus 1 in.

In reading a fractional measurement with a rule, think of the measurement as a major fraction plus or minus a small fraction. For example, $\frac{11}{16}$ in. is $\frac{3}{4}$ in. minus $\frac{1}{16}$; $\frac{5}{16}$ in. is $\frac{1}{4}$ in. plus $\frac{1}{16}$; etc.

Measuring with a rule To measure a certain distance between two points, place the end of the rule exactly on or even with one point, and read the rule at the graduation line on or nearest the other point (see Fig. 3-3). If the end of the rule is worn, start at the 1-in. mark and subtract 1 in. from the rule reading (see Fig. 3-4).

To lay off measurements with a rule, place the end of the rule (or the 1-in. graduation) carefully at one end of the measurement, and then make a fine mark with a pencil or knife exactly even with the desired graduation line on the rule. A knife gives a more accurate marking, but a pencil line is more easily seen and is used for all except the most accurate measurements.

To lay off several measurements in a straight line, it is best to mark off all measurements without raising the rule. If the rule is raised and each measurement made separately, there is a much greater possibility of errors.

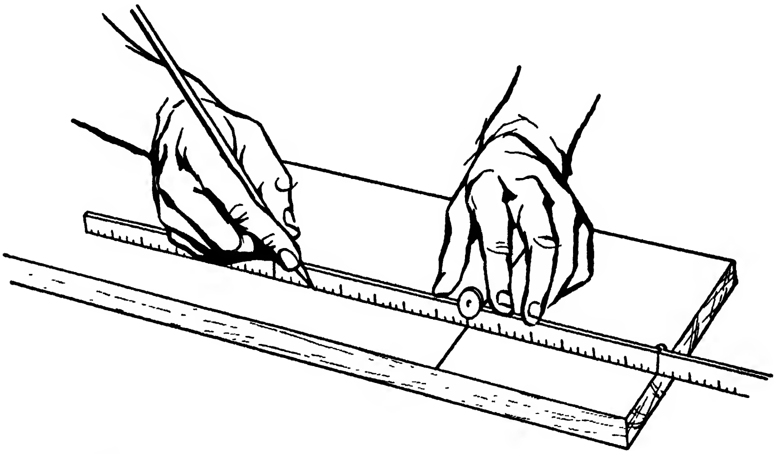


Fig. 3-5. For extremely accurate measuring, lay the rule on edge so that the graduations touch the work being measured. When making several measurements in a straight line, do not raise the rule until all are marked.

For extremely accurate measuring, lay the rule on edge so that the graduations touch the work being marked (see Fig. 3-5).

Marking the middle of a board To locate and mark the middle of a board, place the rule across the board at an angle so that major divisions, such as inch marks, coincide with the edges of the board, and mark midway between these two major divisions. In a similar manner, a board may be divided into three or more equal widths (see Fig. 3-6).

Using the combination square The combination square is one of the most useful tools for measuring, marking, laying out, and checking

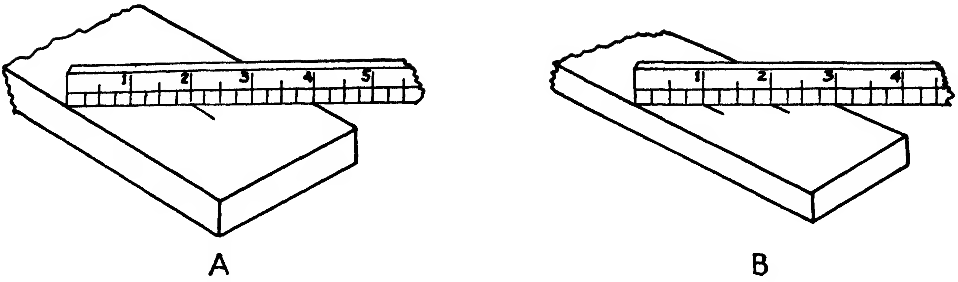


Fig. 3-6. *A*, to mark the middle of a board, lay the rule across it at an angle with two of the inch marks even with the two edges of the board and mark the mid-point as shown. *B*, in a similar manner, a board is easily divided into three or more equal widths.

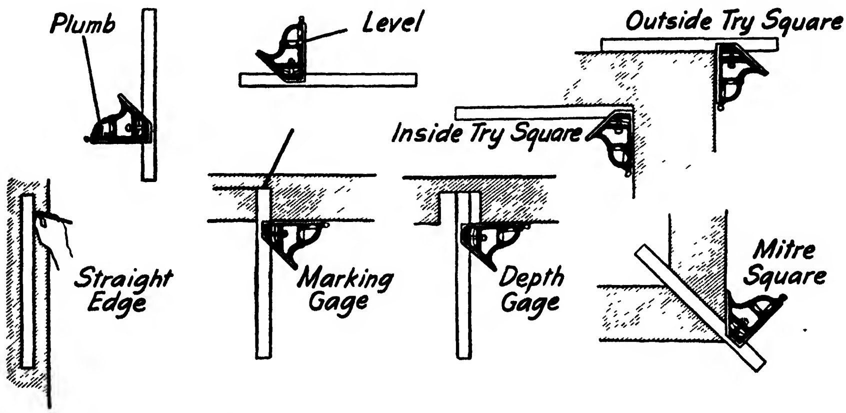


Fig. 3-7. The combination square has many uses in the shop.

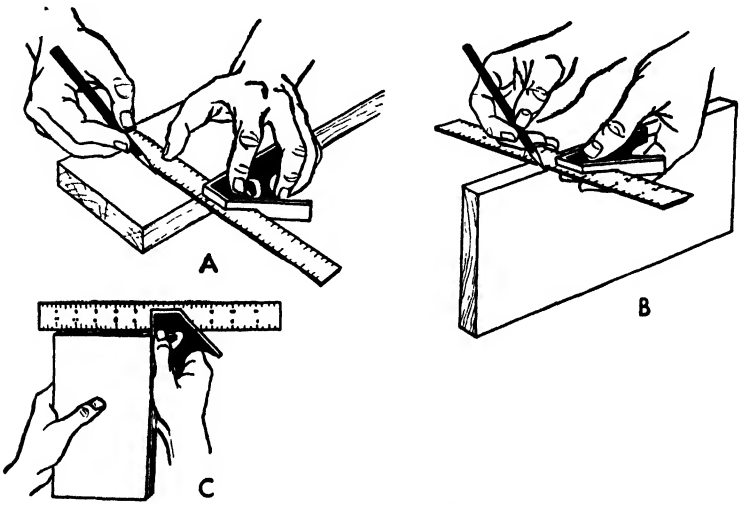


Fig. 3-8. Laying out and checking work with the combination square.

work in the shop. It is used principally as a rule for measuring short distances, as a try square for checking parts to see if they are square, as a straightedge, a level, a plumb, a miter square, a depth gage, and a marking gage (see Fig. 3-7).

In squaring with a combination square or a try square, always hold the handle firmly against the working edge or the working surface (the main edge or surface from which other surfaces are measured or squared).

Laying off angles with the steel square The steel square is a tool of many different uses. It is easily used for measuring distances and laying off and checking right angles. It is also easily used for measuring and

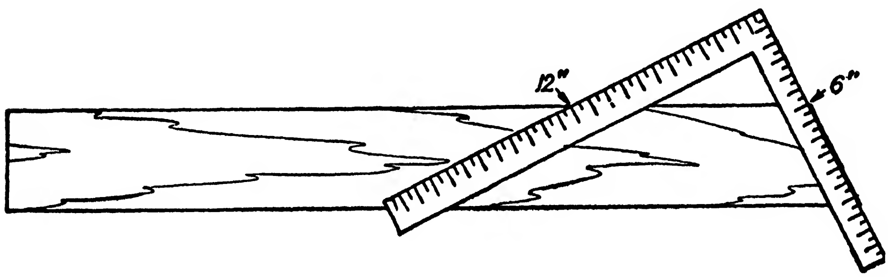


Fig. 3-9. The square is a valuable tool for marking off angles.

duplicating various angles. For example, suppose that a board is cut off at a certain angle and it is desired to cut another board at exactly the same angle. Place the square with the tongue along the end of the board (see Fig. 3-9). Note the readings where both the tongue and the body of the square touch the edge of the board. Place the square on the second board with these same two readings along one edge of the board. A mark along the tongue will give exactly the same angle as on the first board. Take the readings as large as convenient in order to ensure accuracy. For instance, a setting of 12 and 4 would be preferable to 6 and 2 or 3 and 1.

Testing a square If a square is suspected of not being true, it is easily tested. Use a board that has a perfectly straight edge and mark a line across the board (presumably at right angles to the edge). Then turn the square around (see Fig. 3-10) and see if the line still checks square. If not, the square is not true.

If a square is found not true, it may be adjusted by placing the corner of the square flat on an anvil and hammering carefully to stretch the outer or the inner part of the corner as may be required.

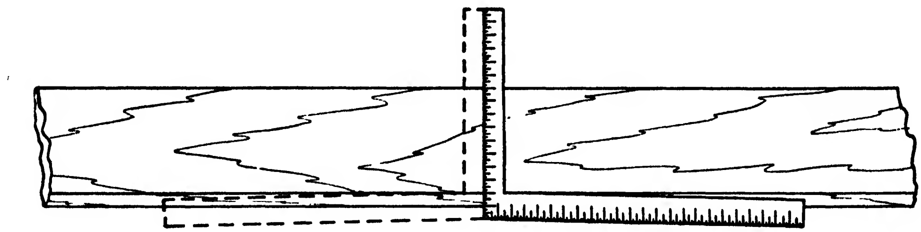


Fig. 3-10. To test a square, select a board with a straight edge and square a line across it. Then turn the square over and see if the line checks square.

Using the bevel The bevel is used for laying out and checking angles and bevels (see Fig. 3-11). The blade is adjustable and is held in place by a thumbscrew. After it is set to the desired angle, it is used in much the same manner as a try square. A good way to set it is to mark off the desired angle on a board, and then adjust the blade to fit the angle.

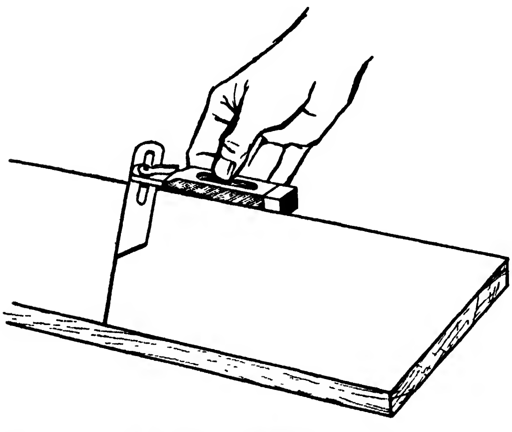


Fig. 3-11. The bevel is used for laying out and checking angles and bevels.

Marking with a pencil or knife To mark with a pencil or knife, first place the square or rule very carefully, and then make a fine narrow line very close to the edge of the square or rule. For most farm woodwork and carpentry a sharp pencil is accurate enough. A hard pencil makes a finer line and stays sharp longer than a soft one. A soft pencil, however, makes a line that is more easily seen and is therefore generally preferred for rough work.

Gaging with the combination square The combination square is very easy to use for gaging lines back a certain distance from the edge of a board. Set the square so that the blade projects the desired distance from the handle. Then move the handle along the edge, while

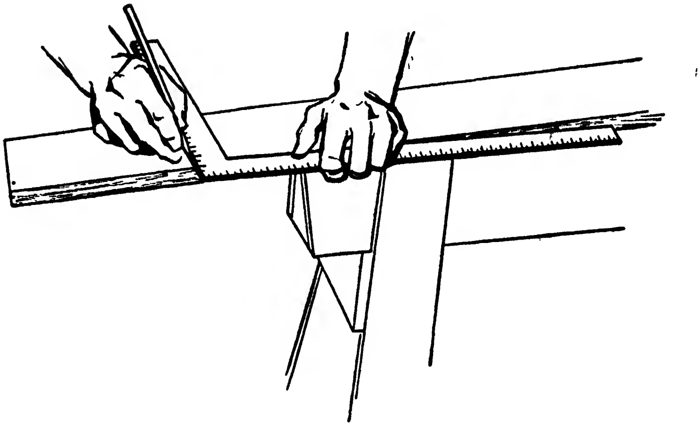
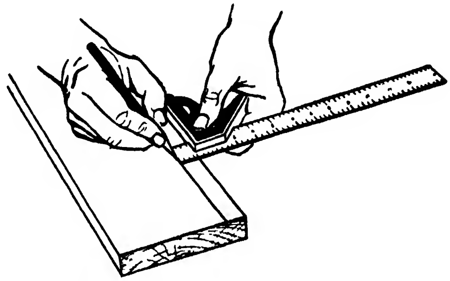


Fig. 3-12. When squaring across a board, hold the body of the square firmly against the edge and mark close to the tongue of the square.

Fig. 3-13. Gaging with the combination square.



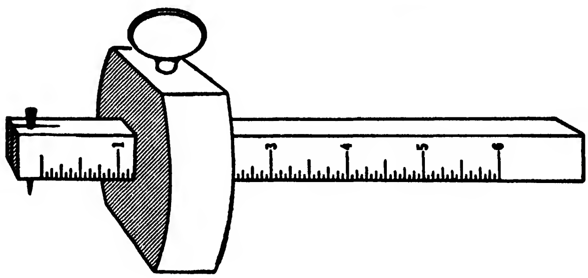


Fig. 3-14. A marking gage. (Stanley Tools)

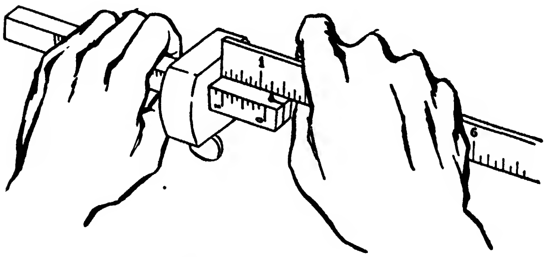


Fig. 3-15. For accurate marking with the marking gage, always check the setting of the gage with a rule.

holding a pencil at the end of the blade (see Fig. 3-13). Be sure to keep the handle firmly against the edge as it is drawn along.

Using the marking gage Where considerable gaging is to be done, it may be desirable to use a marking gage (Fig. 3-14), although a combination square is adequate for most farm shopwork. For accurate work with a marking gage, always check the setting with a rule (see Fig. 3-15). Set the spur to project through the beam about ⅛ in. and keep it sharp so as to make a very fine line.

To use the gage, grasp it with the fingers around the head and with the thumb behind the spur in position to push. Then push the gage forward, holding the head firmly against the surface from which the line is to be gaged, and with the gage rolled slightly forward so that the spur drags at a slight angle (see Fig. 3-16).

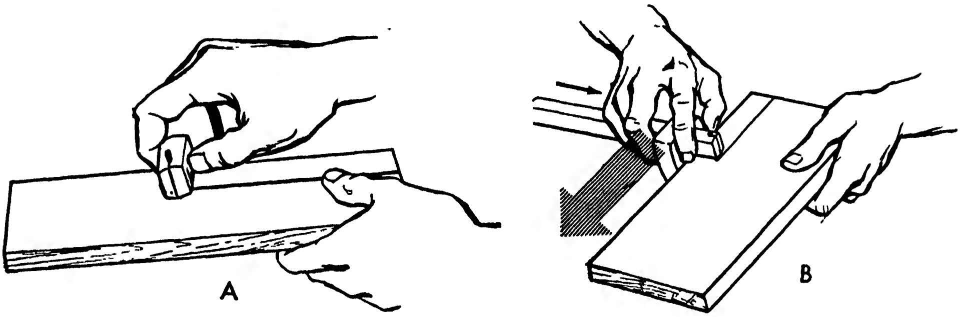


Fig. 3-16. Using the marking gage. Be sure to hold the head of the gage firmly against the edge of the board and to roll the beam slightly forward so that the spur drags at a slight angle.

Gaging with a pencil When a combination square or a marking gage is not at hand, gaging may be done with an ordinary pencil, as follows: Grasp the pencil loosely in the closed fist with the point protruding the desired distance. Then draw the pencil along with the thumbnail firmly against the edge of the board (see Fig. 3-17).

For gaging lines somewhat farther from the edge of the board, use a rule and a pencil. Grasp the rule in one hand with the thumbnail firmly against the edge of the rule at the desired distance from the end. Then draw the rule along with the thumbnail against the edge of the board while a pencil is held in the other hand at the end of the rule (see Fig. 3-18).

Setting and using dividers Dividers are used (1) for marking out circles or parts of circles, (2) for transferring or duplicating short measurements, and (3) for dividing distances into a number of equal parts.

To set a pair of dividers, loosen the thumbscrew and spread the legs to an approximate setting, and then tighten the screw. Finally make

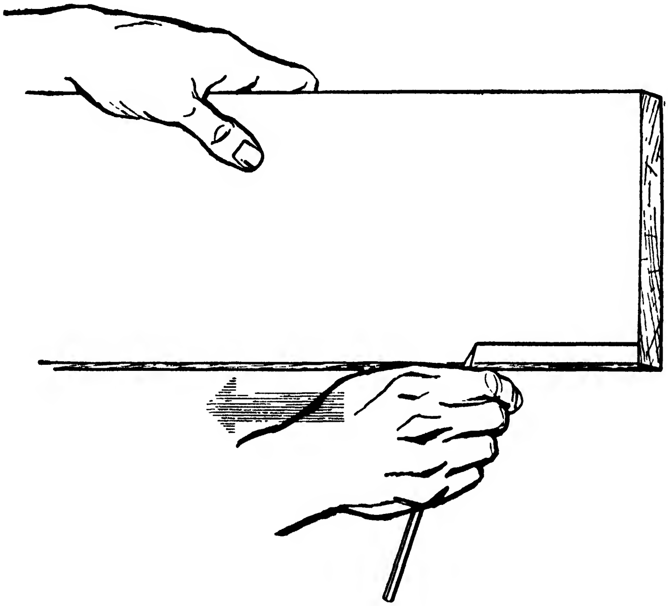


Fig. 3-17. An easy method of gaging a line close to the edge of a board.

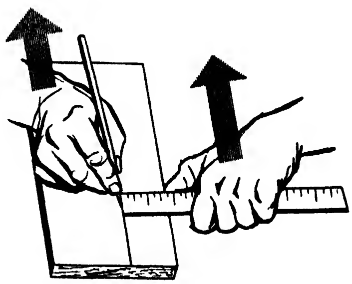


Fig. 3-18. An easy method of gaging a line a few inches from the edge of a board.

the fine, or close, adjustment with the thumb nut at the end of the arc (see Fig. 3-19).

To divide a line into a number of equal parts, say three, set the dividers by guess to one-third the total length. Then check the setting by stepping off three steps to see if they equal the total length. If the

setting is too large, then set the dividers closer by guess, by one-third the distance overstepped on the last step. If the setting is too short, then set the dividers wider. Always check a new setting by stepping off the line again, continuing until the proper setting is obtained.

Laying out duplicate parts; superposition In marking out two or more pieces that are to be alike in all or part of their dimensions, you can save much time and ensure more accurate work by marking all pieces at the same time, or from a pattern (see Fig. 3-20).

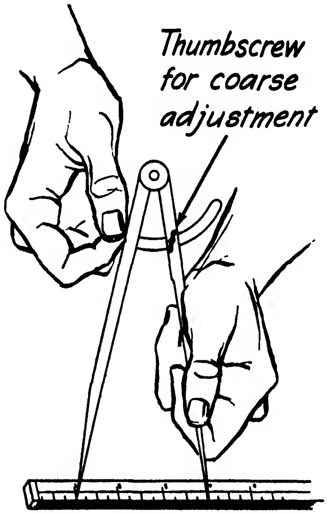


Fig. 3-19. To set a pair of dividers, make an approximate adjustment with the thumbscrew and then make the fine adjustment with the nut at the end of the arc. Steadying the knuckles against the bench top helps to hold the points accurately.

Frequently a piece can be marked for the required sawing, cutting, or boring by superposition, that is, by properly placing the parts together and marking them.

In marking out a number of pieces that are to be alike, rafters for example, the same piece should always be used as a pattern to ensure uniformity.

Laying out irregular designs with patterns Patterns are very convenient for laying out irregularly shaped pieces. Patterns, also called *templates*, are sometimes furnished with plans. When patterns are not available, designs may be sketched on paper, cardboard, presswood, or thin wood boards and then cut out with appropriate tools. For pieces that are symmetrical about a center line, a pattern for only one side, say the right or left half, is sufficient (see Fig. 3-21).

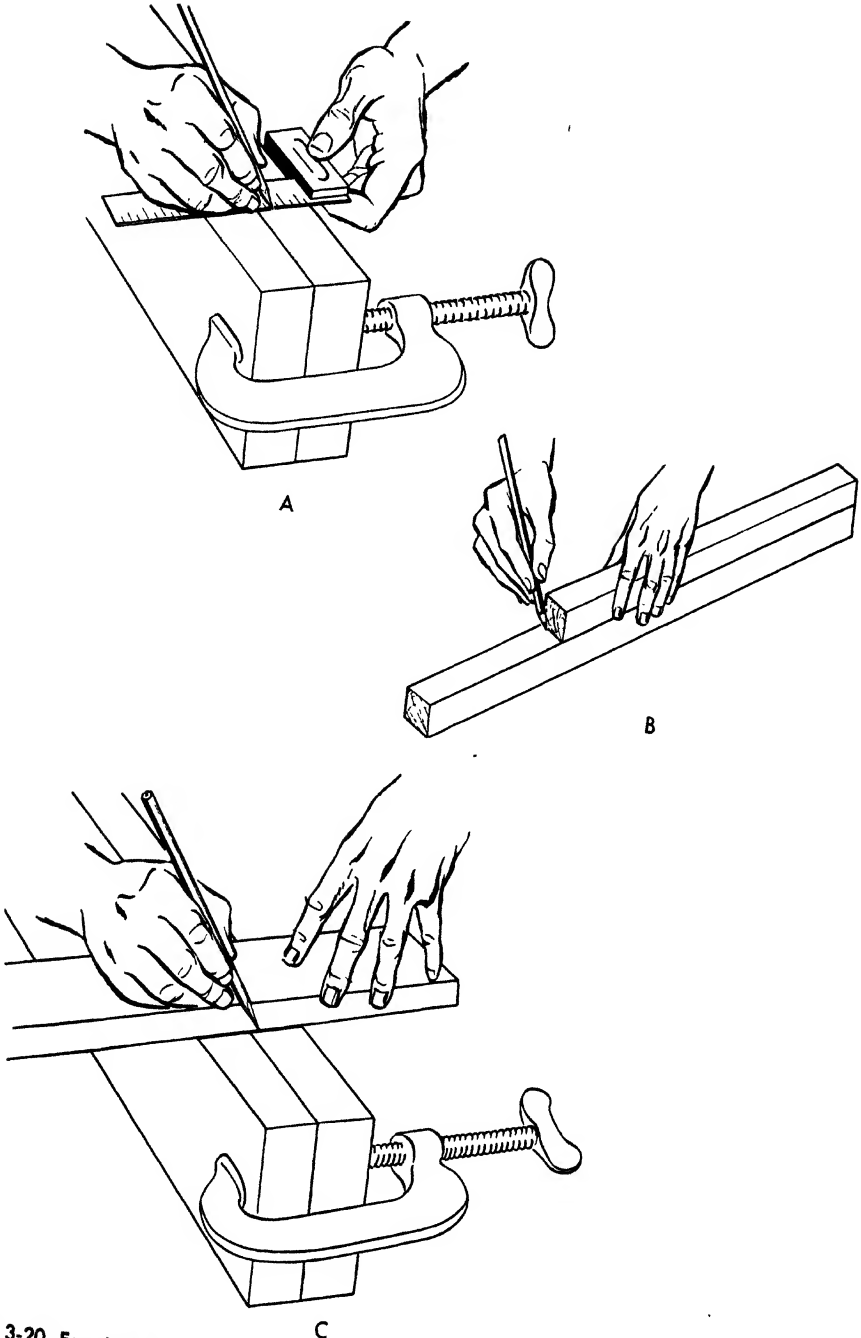


Fig. 3-20. Forethought and planning in laying out duplicate parts save time and ensure accuracy. A, marking duplicate parts at the same time with a square. B, marking duplicate parts with a pattern. (Always use the same piece for the pattern.) C, marking the width of a notch by superposition.

To use such a pattern, simply put it on the material to be cut, hold it firmly in place, and make a mark around it.

Laying out with squares Many drawings and plans for irregularly shaped pieces are made on squared paper. To use such plans, rule off squares of the size indicated, usually 1 in. on a side, either on material

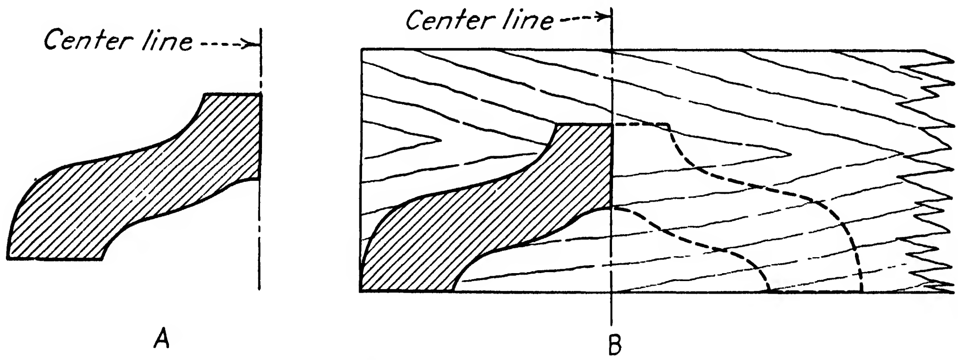


Fig. 3-21. Patterns, or templates, are convenient and ensure accuracy in laying out irregular designs. *A*, a pattern; *B*, the pattern in place for marking the left half. To mark the right half, simply reverse the pattern.

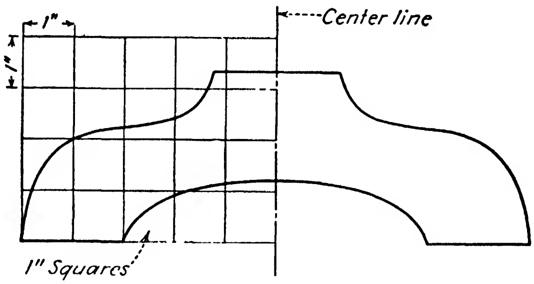


Fig. 3-22. Designs drawn on squares are easily reproduced. First rule squares on material and then sketch in the curves so that they intersect the sides of the squares as on the drawing or plan.

for a pattern, or directly on the material to be used for the article. Then locate and mark the points where the curves intersect the sides of the squares, and sketch the curves smoothly through the points (see Fig. 3-22).

Snapping a chalk line A quick and simple method of marking off a straight line of a floor, wall, ceiling, or piece of lumber is to use a chalk line. It is simply a piece of string or cord that has been rubbed

with chalk to coat it with chalk dust. To use a chalk line, stretch it between the two points that are to be joined by a straight line. (It may be held in place by tying or wrapping around nails, or with the assistance of a helper.) Then lift the line off the surface at a point some-

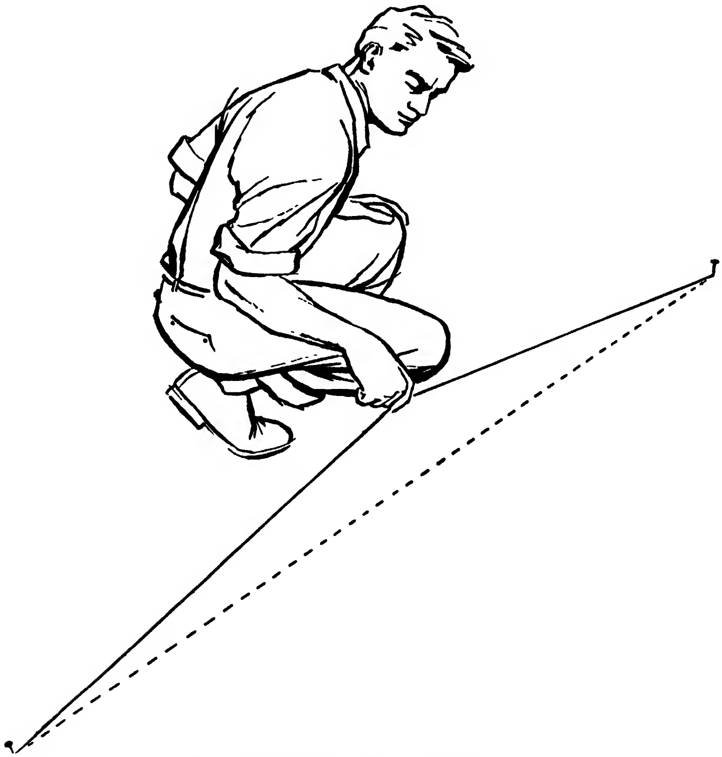


Fig. 3-23. Snapping a chalk line.

where between the two ends, and allow it to snap back into place (see Fig. 3-23). A straight chalk mark is the result.

Using the plumb bob A plumb bob is a pointed weight that may be suspended by means of a cord or string. It is used for locating a point directly beneath another (see Fig. 3-24). To use it, tie the string to a nail or other suitable support, and allow the bob to come to rest. Then mark at the point of the bob. If a plumb bob is not available, a symmetrical weight, like a nut, may be used by carefully suspending it from a string.

The plumb bob may also be used, in connection with a square, for establishing a level line (see Fig. 3-25). Simply allow the plumb bob to

come to rest, and align the body of the square with the string. Then mark along the tongue of the square.

Using and testing a level The carpenter's level is commonly used for marking level lines, for placing the surface of a board in a level plane, and for such work as leveling foundation forms or a part of a machine that must be level for best operation. The bubble vial or tube has a very gentle curvature and is almost filled with a nonfreezing liquid. The tube is mounted so that when the base of the level is horizontal or level the bubble will be in the middle of the tube.

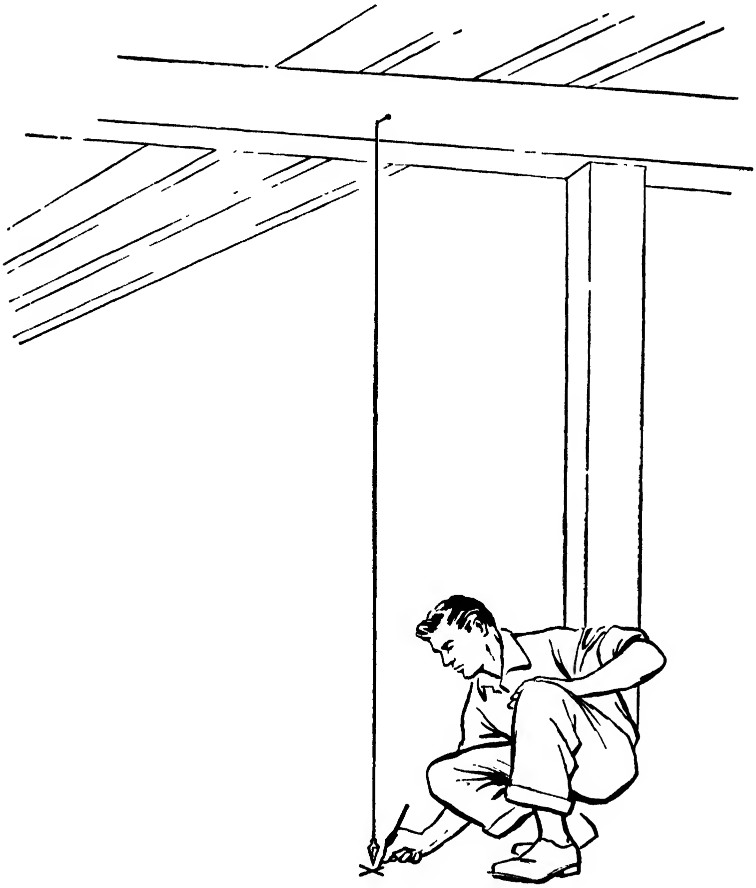


Fig. 3-24. Using the plumb bob to locate a point directly beneath another.

To use a level, simply place it on the surface or part to be leveled, and then raise or lower one end of the surface until the bubble stands in the middle of the bubble tube.

Most levels are equipped with a second bubble tube located near one end. This second tube is mounted perpendicular to the long edges of the level and is used for checking vertical pieces for plumb.

To test a level for accuracy, place it on a bench or some other convenient surface, and wedge up under one end until the bubble comes to the middle of the tube (see Fig. 3-26). Then turn the level end for end. The bubble should return to the middle. If it does not, the level is not in adjustment. Most good levels can be adjusted by turning a screw in one end of the bubble-tube mounting.

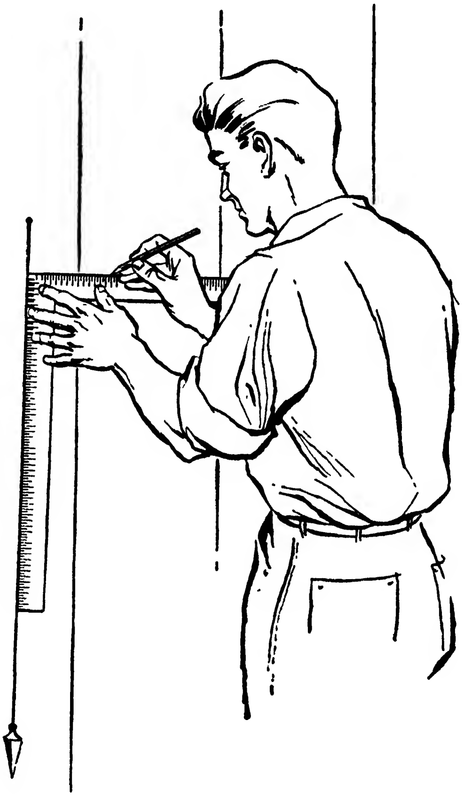


Fig. 3-25. Establishing a level line by means of a plumb bob and square.

Measuring the width of openings Probably the best way to measure the width of an opening, such as a door opening, is to use an extension folding rule or a "push-pull" tape similar to the one shown in Fig. 3-1. To make an inside measurement with such a rule, simply add 2 in. to the reading. If a suitable rule or tape is not available, a convenient way to make the measurement is as follows: Extend two yardsticks or pieces of wood until they just span the opening, as shown in Fig. 3-27. Then read the measurement from the yardsticks, or transfer it to a single board and measure it with a rule or other suitable measuring tool.

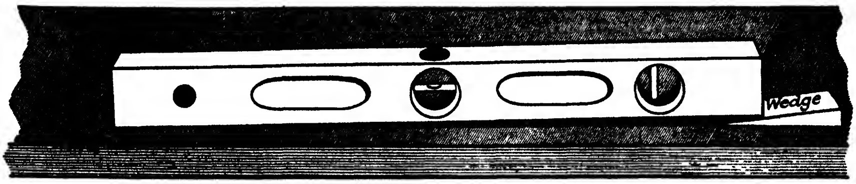


Fig. 3-26. Testing a level for accuracy. Wedge up one end until the bubble is in the center. Then turn the level end for end and see if the bubble is still in the center.

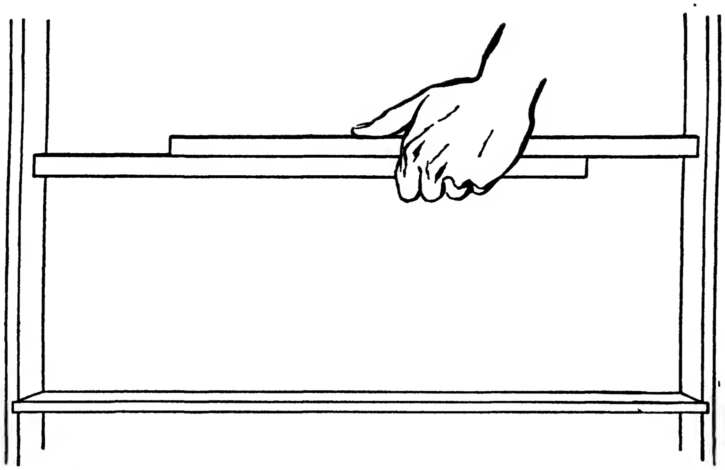


Fig. 3-27. Measuring the width of an opening.

3. SAWING WOOD WITH HANDSAWS

The proper method of using the saw is not difficult to learn, and everyone studying shopwork should early master the art of sawing.

The first requirement for satisfactory work with the saw is that it be in good condition. Creditable work cannot be done with a saw that is dull or poorly filed or set (see Chap. 7, "Sharpening and Fitting Tools," pages 235 to 246 on sharpening saws). If the workman cannot or does not wish to sharpen his own saw, he should have it sharpened by a competent mechanic.

Holding the saw; sawing position Grasp the handle of the saw firmly, yet not tightly. Let the forefinger extend along the side of the handle, and not through the handle with the other fingers. This enables one to guide the saw more easily and accurately.

Stand back from the work a little and in a position so that a line across the chest and shoulders is at an angle of about 45 to 60 deg with the line of sawing. Place the saw, arm, elbow, shoulder, and right eye (for a right-handed workman) all in the same vertical plane (see Fig. 3-28). In this position, the saw can be more easily controlled and made to follow a straight line and cut perpendicular to the surface of the board.

Starting the hand crosscut saw To saw off a board, clamp it in a vise, or hold it firmly on a box or sawhorse with the left knee (in the

case of a right-handed workman). Grasp the far edge of the board with the left hand, using the thumb to guide the saw while starting the cut (see Fig. 3-29). Make two or three backstrokes, lifting the saw on the forward strokes. Draw the saw back slowly and carefully just where the cut is to be made.

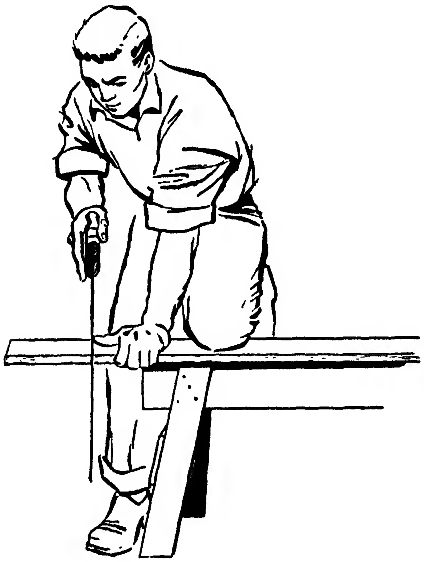


Fig. 3-28. The saw, arm, elbow, shoulder, and right eye should all be in the same vertical plane.

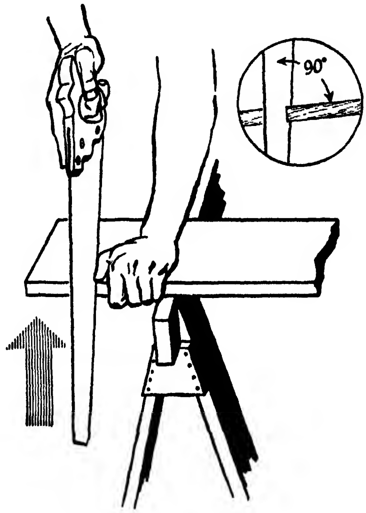


Fig. 3-29. Start the saw cut with two or three backstrokes. Guide the saw with the thumb and hold the blade square with the board.

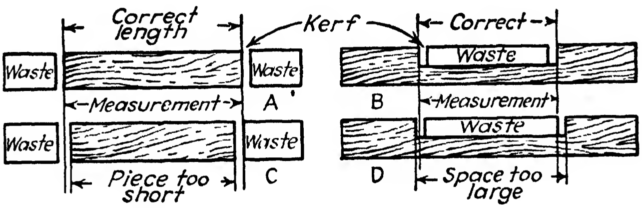


Fig. 3-30. Be sure to saw carefully on the waste side of the line, as at *A* and *B*. Sawing on the line or on the wrong side of the line makes the stock too short, as at *C*, or the opening too large, as at *D*.

Do not start the saw cut, or kerf, on the line, ***but beside the line in the waste material*** (see Fig. 3-30), leaving the line itself. If the piece is to be finished with a plane, make allowance for this and saw a *little* farther from the line. Removing excess waste with a plane, however, is tedious work and should be kept to a minimum.

Sawing off a board After the saw is started, push it forward and pull it back, using *long, easy* strokes and *light pressure.* Do not work too fast. Short, fast, choppy strokes are signs of an amateur or careless workman.

Hold the saw at an angle of about 45 deg with the board (see Fig. 3-31). If the saw tends to go to one side of the line, twist the handle slightly and gently to make it come back to the line gradually as the sawing proceeds (see Fig. 3-32). If it cannot be made to follow

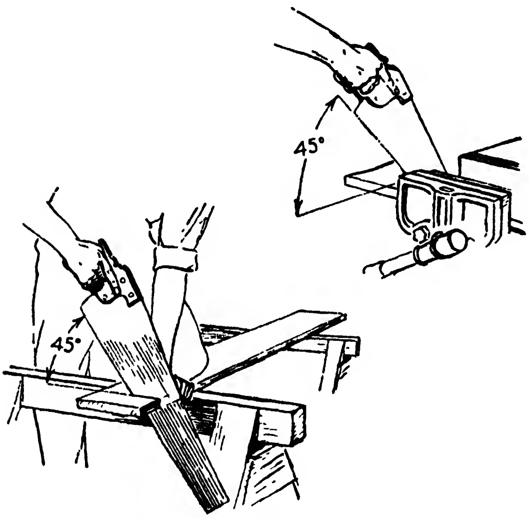


Fig. 3-31. About 45 deg is the correct angle between the saw and the work for crosscut sawing. (Stanley Tools)

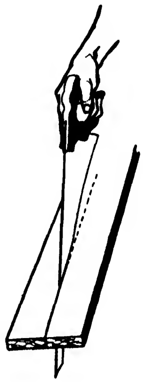


Fig. 3-32. If the saw leaves the line, twist the handle slightly and gradually draw it back to the line.

a straight line, the set may not be enough, or it may be uneven, the teeth on one side being bent out more than those on the other.

Keep the blade square with the surface of the board. Testing occasionally with the square may be advisable (see Fig. 3-33). If the saw is getting off square, bend it a little (do not twist) to straighten it gradually as the sawing proceeds (see Fig. 3-33*A*).

If heavy pressure is used, or if short, quick strokes are made, there is danger of catching the saw and bending or kinking the blade. It will also be much more difficult to saw a straight line. If heavy pressure is required, the saw needs sharpening.

In order to prevent splintering just as the saw is about to finish the

cut, hold up the outer end of the board (see Fig. 3-34) and use short easy strokes.

Using the ripsaw The ripsaw is used for cutting lengthwise of the grain. It is used in practically the same manner as a hand crosscut saw, except that the cutting edge should make a steeper angle with the surface of the board—about 60 deg instead of 45 (see Fig. 3-35).

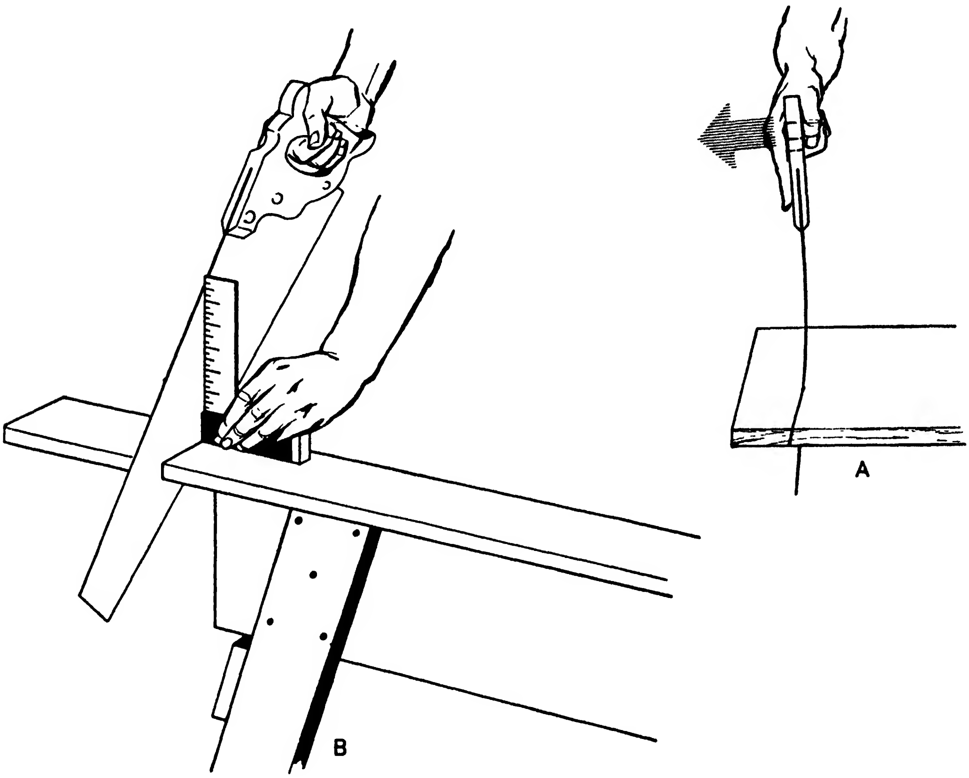


Fig. 3-33. It is best for the beginner to check his work occasionally to see that he is making a square cut. If he is not, he should bend the saw a little, as shown at A, to straighten the cut as the sawing proceeds.

A good method of holding a board for ripping is to place it lengthwise on a sawhorse, or between two sawhorses, and hold it in place with the knee. Use a small wedge in the saw kerf if the blade binds.

If a ripsaw is not available, a crosscut saw may be used for an occasional job of ripping, but it will be slower and require more work than a ripsaw.

Sawing curves The *compass saw* is useful in sawing curves, especially inside curves where the cut must be started in a hole bored with an auger bit (see Fig. 3-36). In sawing sharp curves, use short strokes and do most of the sawing near the end of the blade where it is narrow. Be careful not to catch the blade and bend it. Saw with the cutting edge perpendicular to the surface of the board and not at an angle as with other saws. For accurate work or where a smooth surface

Fig. 3-34. Support the outer end of the board as the saw finishes the cut to avoid splintering.

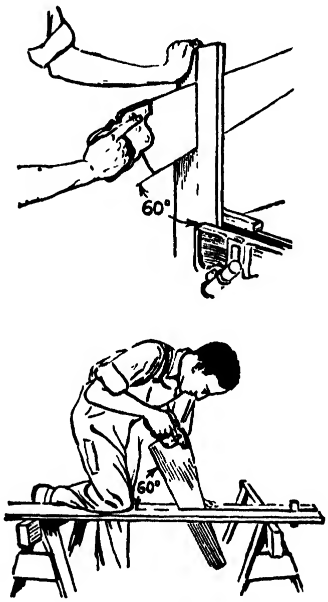


Fig. 3-35. About 60 deg is the correct angle between the saw and the work for ripsawing. (Stanley Tools)

must be left, do not saw too close to the line, but leave about $\frac{1}{16}$ in. or somewhat less to be removed with other tools, such as the spokeshave or wood file. It is difficult to saw exactly to the line and leave a smooth cut.

The *coping saw* has a light, thin, short blade held in a frame and is used for sawing curves in thin material. The blade may be inserted to cut either on the pull stroke or on the push stroke. Cutting on the pull stroke is less apt to kink or break the blade. Long, steady, moderately slow strokes should be used. Short, fast strokes are apt to overheat the blade.

Sawing with a coping saw can usually best be done by holding the work level, allowing it to project over the bench top or supporting it in a "saddle" or V-shaped bracket held in a vise as shown in Fig. 3-37. The sawing is then done with the handle below the work and the blade inserted to cut on the pull or downstroke.

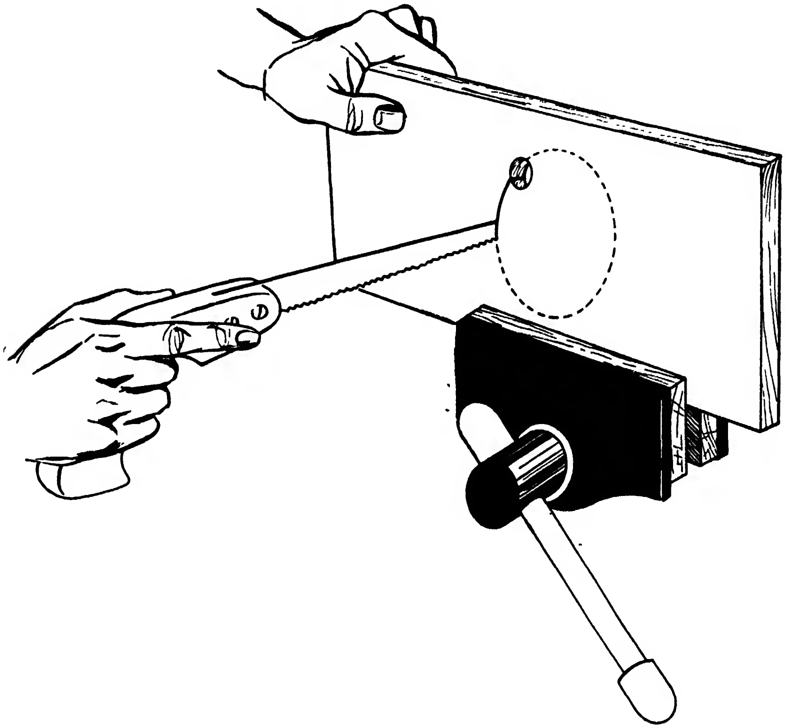


Fig. 3-36. The compass saw is used for sawing curves.

When sawing has progressed as far as the frame of the saw will permit, it is usually possible to turn the blade a quarter turn in the frame and saw farther.

Sawing miters Miters are easily sawed with a handsaw and a miter box. If a factory-made miter box is not available, one can be easily made in the shop according to the plan shown in Fig. 3-38. In making a miter box, be sure to square up the bottom board carefully, so that the two sides will be parallel to each other and square with the bottom board when the box is assembled. It is important also to mark out and saw the cuts carefully.

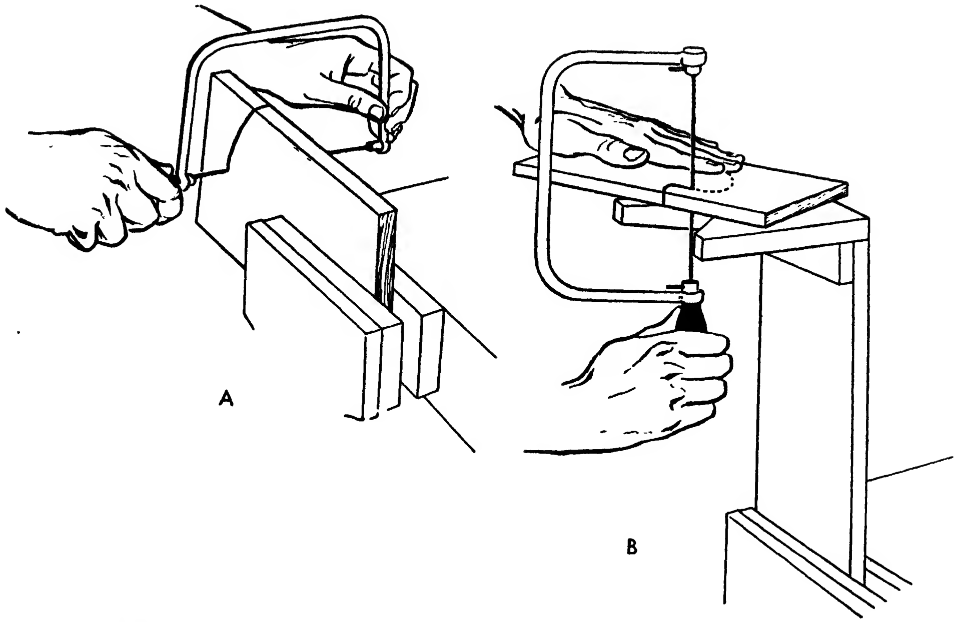


Fig. 3-37. The coping saw is useful for sawing curves in light work. Although the work may be held in a vise, as at *A*, it is usually better to use a bracket or saddle, as at *B*, with the blade inserted in the saw frame to cut on the downstroke.

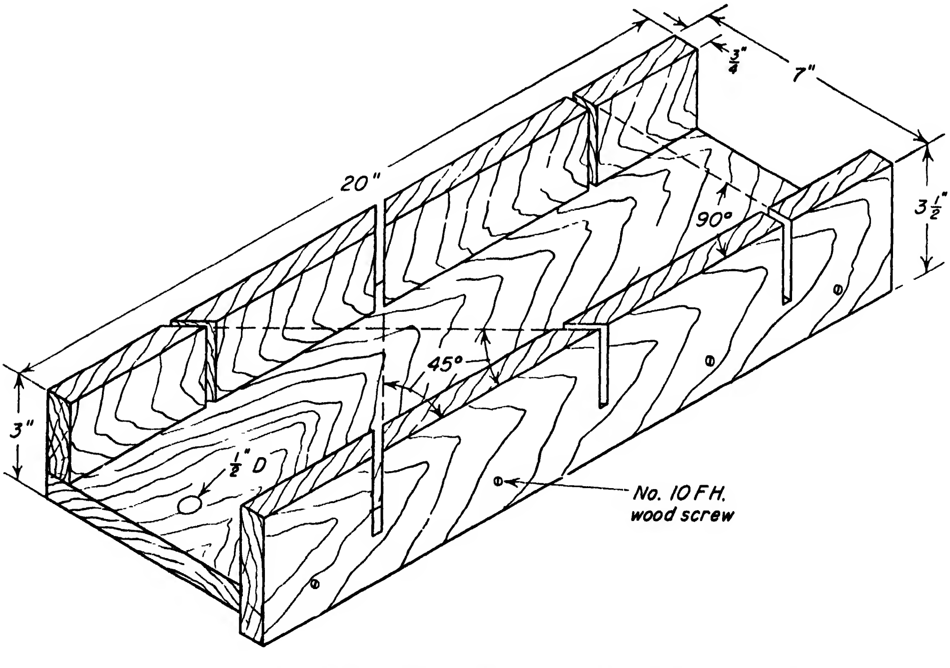


Fig. 3-38. A miter box is a useful piece of equipment that is easily made in the shop.

4. PLANING AND SMOOTHING WOOD

A plane will not produce good work unless it is sharp and properly assembled and adjusted. (See Chap. 7, "Sharpening and Fitting Tools," pages 213 to 219, for information on sharpening.)

Assembling the standard plane Fasten the plane-iron cap to the flat side of the plane iron, allowing the cutting edge to project about

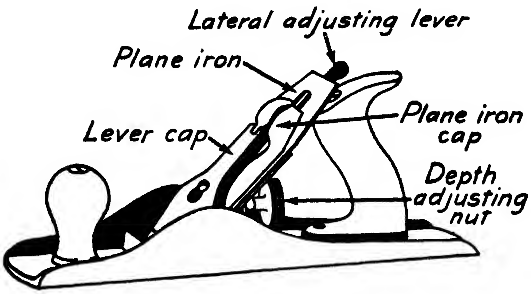


Fig. 3-39. Parts of the standard plane.

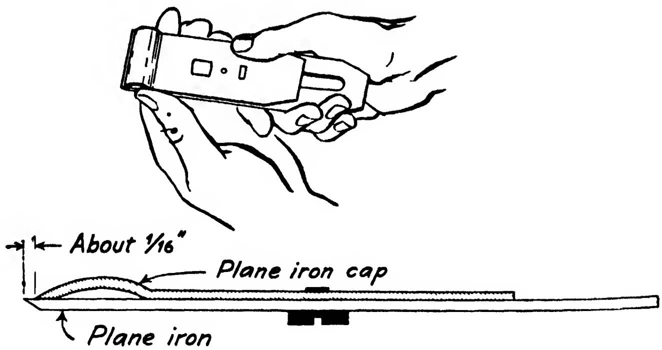


Fig. 3-40. For average work, set the plane-iron cap back about 1/16 in. from the cutting edge of the plane iron.

1/16 in. beyond the plane-iron cap (see Fig. 3-40). Turn the screw tight to hold these two pieces firmly together and thus prevent shavings from wedging between them and possibly causing the plane to choke.

Place the assembled plane iron and plane-iron cap in the throat of the plane, with the plane iron down (see Fig. 3-41). Put the lever cap in place on top of the plane-iron cap, and clamp it down. Be sure the lever cap fits down securely. If it does not, tighten the lever-cap screw a little.

Adjusting the plane There are two main adjustments on the standard plane. The knurled nut just in front of the handle is to regulate the depth of cut; and the lateral adjusting lever just under the back end of the blade is to straighten the blade in the plane to make it cut the same depth on both sides.

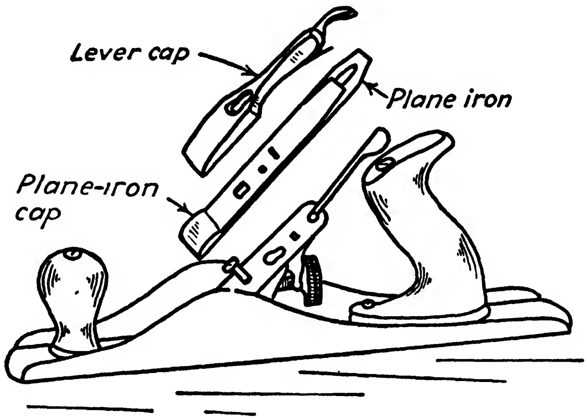


Fig. 3-41. Assemble the plane with the beveled edge of the plane iron down.

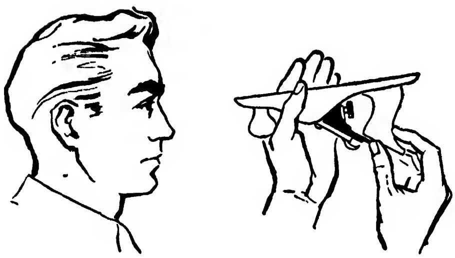


Fig. 3-42. To make a trial adjustment, turn the plane upside down and sight along the bottom. The blade should project through evenly and just about the thickness of a sheet of paper

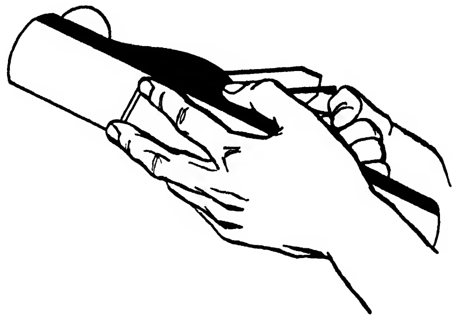


Fig. 3-43. A good way to check the setting of a plane is to feel it with the fingers.

To make a preliminary or trial adjustment, turn the plane upside down, holding the front end toward you, and sight along the bottom (see Fig. 3-42). Turn the depth-adjusting nut until the blade projects through about the thickness of a sheet of writing paper, and move the adjusting lever until the blade projects through the throat evenly on

both sides. It is well also to check the adjustment by feeling the corners of the bit with the first two fingers of one hand (see Fig. 3-43). If one corner projects through the throat farther than the other, it can be easily detected by this method.

Using the plane Grasp the handle of the plane with the right hand and the knob with the left hand, palm on top (see Fig. 3-44). Stand with the right side to the bench, feet apart, and with the left foot slightly ahead (see Fig. 3-45). As the plane is pushed forward, gradually shift weight to the left foot. Keep the forearm straight in line

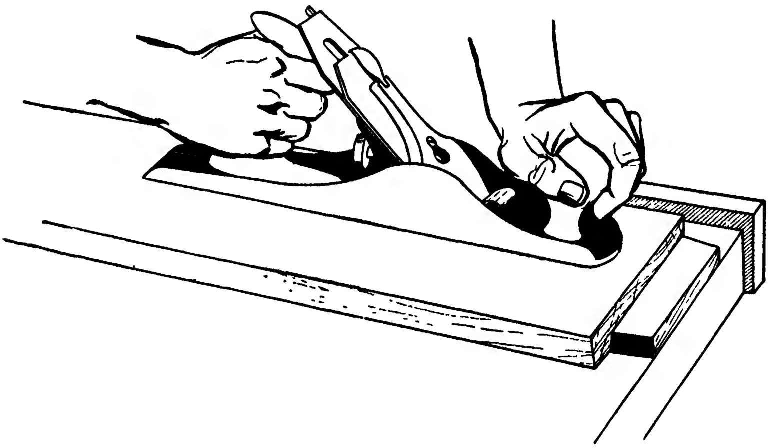


Fig. 3-44. Hold the plane with the left palm on the knob and with the right forearm pushing straight in line behind the plane.

behind the plane. In this manner, you can best control the plane and work with least fatigue.

Plane with the grain Before starting to plane, always examine the board to see which way the grain runs, and then plane with the grain. If there is doubt as to which way the grain runs, a stroke with the plane will quickly indicate the direction. An attempt to plane against the grain will result in rough work and possibly in choking the plane. Sometimes, because of irregular grain, it may be necessary to plane part of the board in one direction and the remainder in another.

Hold the board properly Hold the board being planed by clamping it securely in a vise if possible, or by placing one end against a stop or a block on the top of the bench. A thin strip of wood may be nailed to the bench top to serve as a stop when planing a wide board (see Fig. 3-44).

A V block, like that shown in Fig. 3-50, is convenient for holding a board for edge planing when a vise is not available.

Use the planing stroke To start the plane at the end of a board, press down firmly on the knob of the plane and push forward on the handle. As the plane goes over the other end of the work, finishing the stroke, gradually release pressure on the knob and be sure to hold the back of the plane down firmly (see Fig. 3-46). Thus the board can be planed straight all the way across.

Fig. 3-45. In planing, stand with the right side to the bench, feet apart and with the left foot slightly ahead of the right. As the plane is pushed forward gradually shift more weight to the left foot.

Do not plane too deep Keep the plane set to cut a thin shaving, except in smoothing rough lumber or in removing considerable waste. Even in such cases, it is best to set the plane shallow for the finishing cuts. A common mistake among beginners is to set the plane too deep, which results in gouging and rough, uneven work.

Lay the plane on its side When not in use, lay the plane on its side (see Fig. 3-47). This prevents the cutting edge from being dulled by contact with a gritty bench top. When putting the plane away, place a thin strip of wood under the front end to keep the cutting edge off the tool chest or case; or else turn the depth-adjusting screw to draw the plane iron well up into the throat of the plane and thus protect it.

Planing a surface Begin at one edge of the board and plane with full-length strokes, working to the other edge. When the plane takes a thin shaving all over the board, and has touched all points of the surface, test it to see if it is true.

To make the test, place a straightedge, such as the edge of a steel square, in various positions on the surface, sighting under it to locate the high and low places. First place the straightedge crosswise on the board and move it slowly from one end to the other while sighting (see Fig. 3-48*A*). Then place the straightedge lengthwise and move it slowly from one edge to the other (see Fig. 3-48*B*). Finally place the straightedge on one diagonal and then on the other.

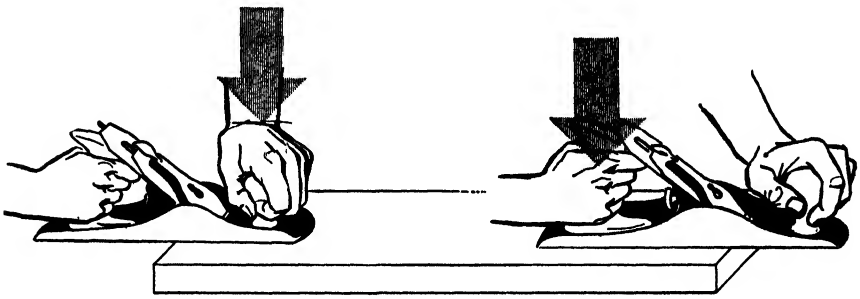
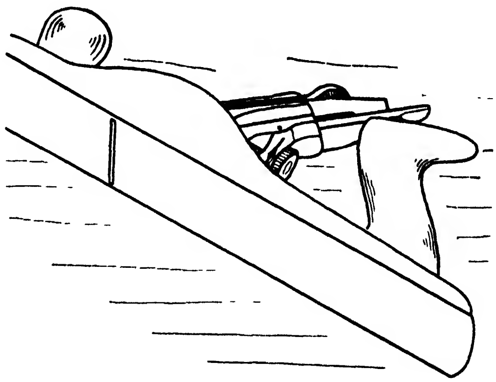


Fig. 3-46. Press hard on the knob at the beginning of the stroke and hard on the back of the plane at the end of the stroke. This makes the plane cut straight all the way across.

Fig. 3-47. To prevent the dulling of the cutting edge, lay the plane on its side when not in use.



When the amount of light that can be seen under the straightedge in all positions is about the same, the surface may be considered true.

Remove the planer or mill marks When planing a piece that is to be varnished or finished by staining and waxing, be sure to remove all traces of the planer marks left by the planing mill. Any such marks can be detected by holding the board up to the light and moving it about slowly. These marks will appear as a series of small hollows and ridges and, if not removed by planing, will be magnified by varnishing or

polishing. Such marks left on a finished piece suggest careless workmanship.

Planing an edge straight and square with an adjoining surface It is frequently necessary in woodworking to plane the edge of a board to make it (1) straight and (2) square with an adjoining surface. Beginners should therefore early master this simple but important operation.

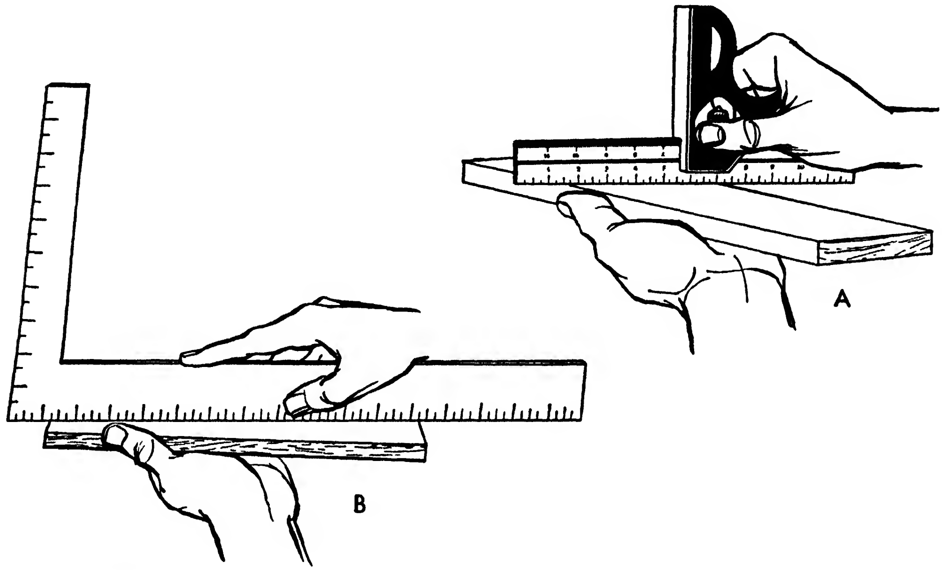


Fig. 3-48. Testing to see if the surface is a true plane. Move the straightedge from end to end, as at *A*, and from edge to edge, as at *B*, then place it on one diagonal and then on the other. About the same amount of light should be seen under the straightedge in all positions.

Before starting to plane an edge to straighten it, sight along it to note the location of any high spots. Plane down such high spots first, and then take long strokes extending the full length of the board if possible. Be sure to keep the front end of the plane down firmly at the beginning of the stroke and the back end down firmly at the finish (see Fig. 3-46).

In planing an edge, be sure to *keep the bottom, or sole, of the plane square with the side of the board.* A simple way of doing this is to hold a small square-edged block under the front of the plane and against the side of the board (see Fig. 3-49*A*). Another good way, commonly used by experienced workmen, is to allow the fingers of the left hand

to project down under the plane and rub along the board (see Fig. 3-49*B*). This helps to steady the plane and keep it square with the side of the board.

A block with a V-shaped notch in the end when nailed to the bench top (see Fig 3-50) is excellent for holding boards for edge planing.

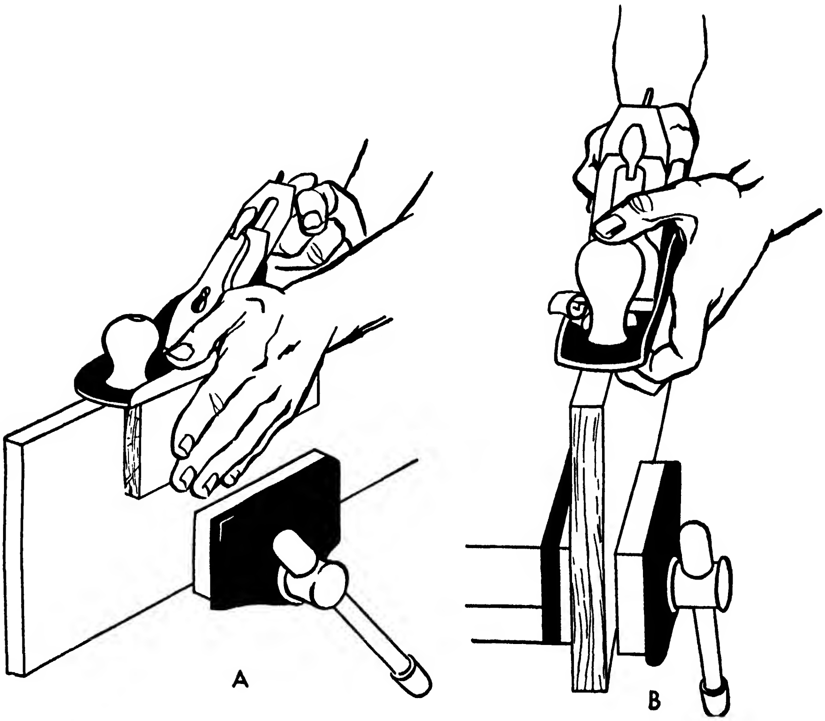


Fig. 3-49. Two good methods of holding a plane while planing an edge square with a surface.

As the planing proceeds, check the edge frequently for straightness by sighting or using a straightedge, and for squareness by using a square.

Planing end grain To plain end grain, be sure the plane is very sharp and set extremely shallow. If it is dull, or if it is set too deep, it will gouge and jump, causing rough, uneven work.

Hold the plane at an angle of about 45 deg to the board (see Fig. 3-51), and push it along sidewise and parallel to the end—not in the direction the plane points. This gives an oblique or drawcutting action and better enables the workman to control the plane.

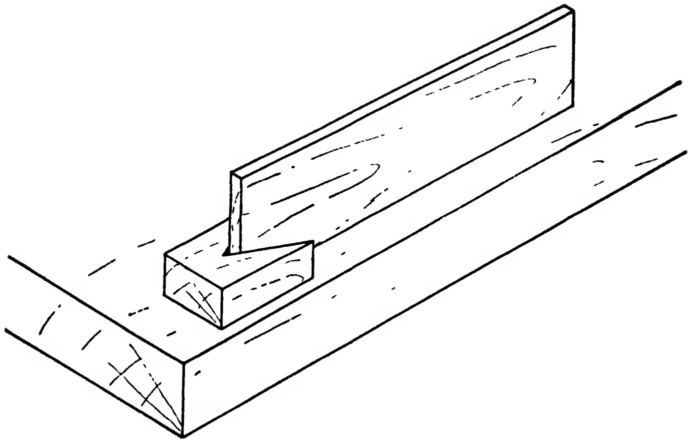


Fig. 3-50. A good way to hold a board for edge planing.

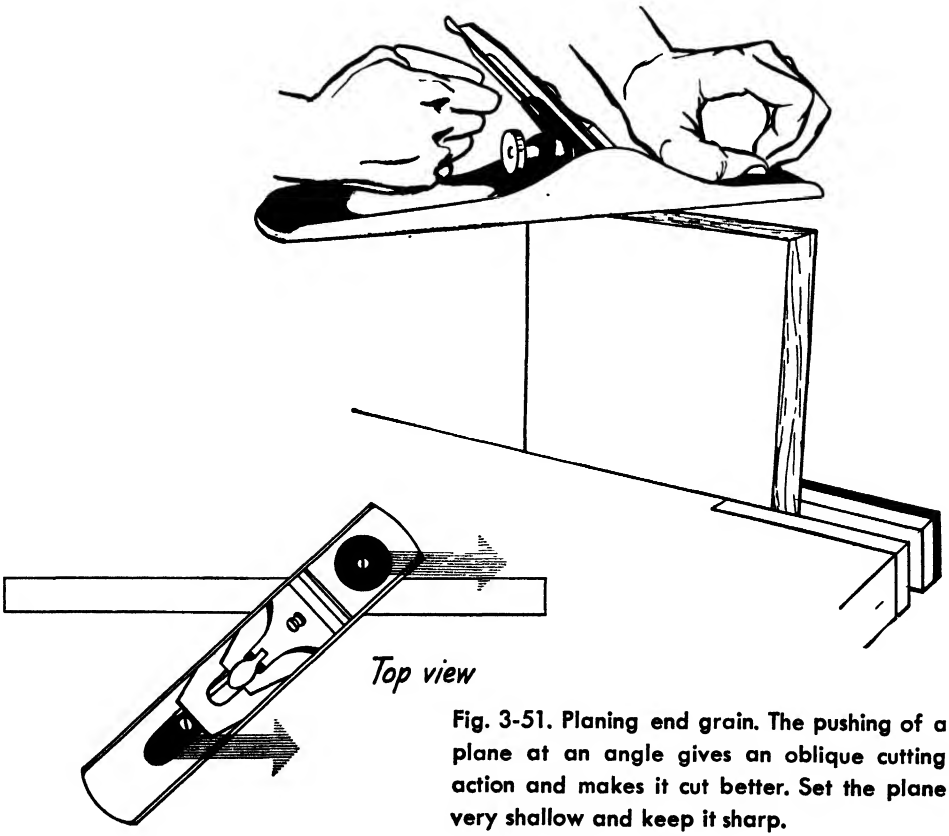


Fig. 3-51. Planing end grain. The pushing of a plane at an angle gives an oblique cutting action and makes it cut better. Set the plane very shallow and keep it sharp.

To avoid splintering the edge of the board, clamp a small block of scrap material on the edge as shown in Fig. 3-52. If such a method cannot be used, plane the end of the board partly from one edge and the remainder from the other edge, or chamfer the far edge as shown in Fig. 3-53.

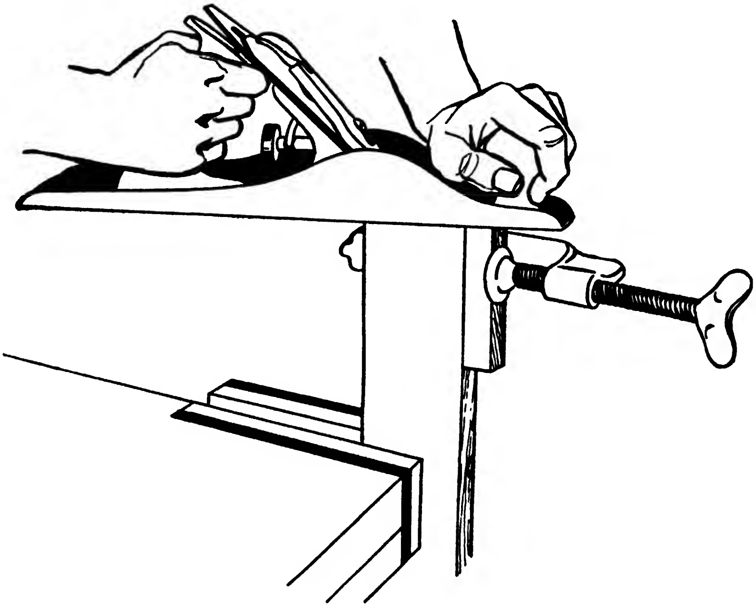


Fig. 3-52. Clamping a block of scrap material on the far edge prevents splintering when planing end grain. Another method is to plane part from one edge and part from the other.

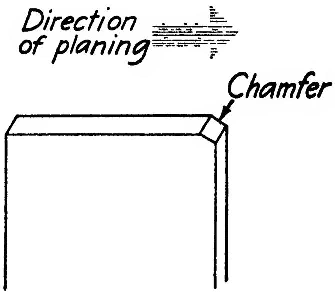


Fig. 3-53. A piece of wood chamfered on the far edge to prevent splintering when the end is planed.

Check the work frequently as the planing proceeds, sighting or using a straightedge in checking for straightness and using a square in checking for squareness. It is the mark of a careful workman to remove as little material as possible in straightening and squaring his work.

For square planing the ends of small pieces, the homemade miter

box, or a bench hook (see Fig. 3-54), may be used as an aid. Hold the piece firmly against the backstop, allowing the end to project a little—almost not at all—beyond the edge of the bench hook. Then push the plane entirely across the end.

The block plane is excellent for planing end grain (see page 79).

Smoothing end grain with a file The use of the file for smoothing and squaring the ends of boards should usually be discouraged. If the end has been carefully marked and sawed, very little smoothing and squaring will be required; and such as is needed can usually be much

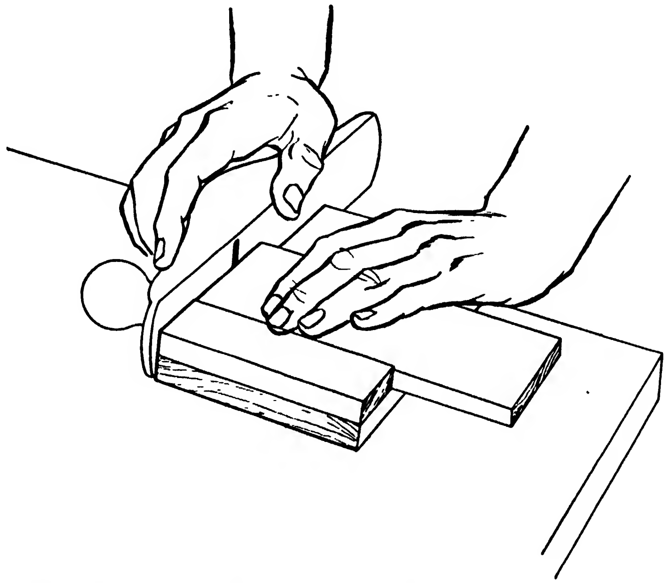


Fig. 3-54. The ends of small pieces may be planed with the aid of a bench hook.

better done with a plane. When a file is used, however, it should be used properly. Proper use ensures not only better work, but also faster and easier work.

In using a file, *use long, steady strokes*—not short, quick, jerky ones. Also, lift the file slightly, or release the pressure, on the backstroke. When filing narrow surfaces, put more pressure on the front end of the file as it starts the stroke, and gradually shift the pressure until more is on the handle end of the stroke. In this manner it is much easier to control the file and work the end down straight and square.

Use a file for removing only small amounts of waste. Where more than just a little is to be removed, use a plane or other suitable tool.

Squaring up a board By squaring up a board is meant making all sides, ends, and edges smooth, true planes at right angles to adjoining surfaces. (A true plane is one that has all points in the same plane. A surface may be smooth, yet not true. See page 69 for methods of testing a surface for trueness.)

For most woodwork jobs on the farm, mill-planed lumber will be near enough true and square and will be smooth enough without planing. Some jobs, however, require greater accuracy and smoother work than can be done with the lumber at hand, and the pieces will need to be partly if not completely squared up.

The method of squaring up a board is as follows:

1. Plane one broad surface smooth and true. This surface is then known as the *working surface*. Mark it with one short line some-

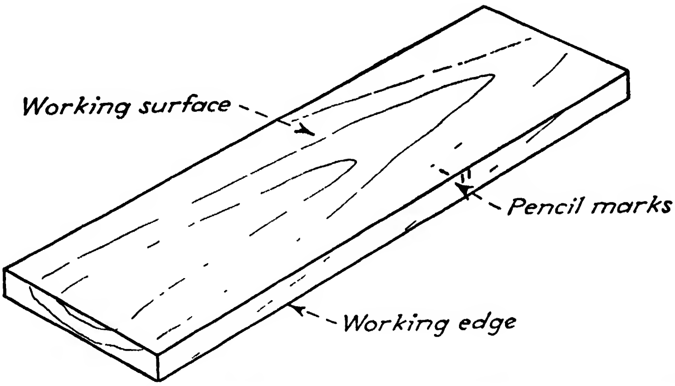


Fig. 3-55. A board properly marked to designate (1) the working surface and (2) the working edge. With the marking done as indicated, one may tell which is the working surface and which is the working edge by a glance at either.

where on the surface, but near the edge that is to be selected for the working edge and extending to this edge (see Fig. 3-55). The first step should not be considered complete until the marking is done. If inspection or test shows the board to be true and smooth enough for its purpose without planing, then the working surface is simply marked.

2. Select the best edge for the working edge, and plane it (*a*) straight and (*b*) square with the working surface. Test for straightness with a straightedge or by sighting, and test for squareness with a square. This edge is called the *working edge*. Mark it with *two* short lines extending to the working surface. If the edge is already straight

and square with the working surface, simply mark it. (With the marking done as indicated, one may tell which is the working surface and which the working edge by a glance at *either.*)

3. Make the second edge parallel to the working edge. It will then be (*a*) straight and (*b*) square with the working surface. Probably the easiest way to perform this third step is to gage (or otherwise mark) for the desired width, marking on both the working surface and the opposite surface, and then plane to the gage lines or marks.
4. Mark and cut one end (*a*) straight, (*b*) square with the working surface, and (*c*) square with the working edge. Always hold the handle of the square firmly against either the working edge or the working surface in marking around a board. Saw very carefully and very close to the lines.
5. Mark the piece for the desired length, and cut the second end like the first one, making it (*a*) straight, (*b*) square with the working surface, and (*c*) square with the working edge.
6. Gage for thickness and plane to the gage lines, making the second surface parallel to the working surface. This step is usually omitted except when working with very rough lumber.

Many workmen prefer to perform the operations of squaring up a board in the order given above. After the working surface and the working edge are established, however, the remaining steps may be performed in any order.

Marking and planing a chamfer A chamfer is a straight flat surface produced by cutting away the arris, or sharp edge, formed by the meeting of two surfaces. A chamfer is used to improve the appearance of a piece or to lessen the danger of splintering when in use, or both. To make a chamfer, first mark it out by gaging lines back from the arris a uniform distance, usually about $\frac{3}{16}$ to $\frac{1}{4}$ in. (see Fig. 3-56). The marking can be done with a combination square and a pencil, or with a rule and a pencil, or even with a pencil alone (see Figs. 3-13, 3-17, and 3-18). The marking gage with the regular steel point or spur is not suitable for marking out chamfers, because it leaves a scratch or mark that is difficult to remove. A marking gage may be used, however, by filing a small notch in the end of the beam and holding the point of a pencil in the notch as it is moved along (see Fig. 3-57).

Plane those chamfers which are on the sides of a piece first, and

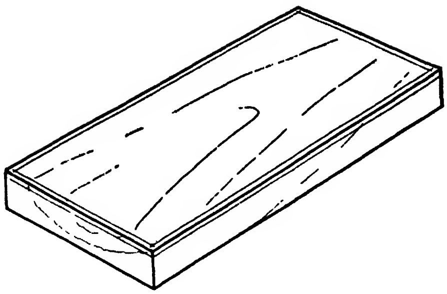


Fig. 3-56. A piece marked preparatory to cutting a chamfer.

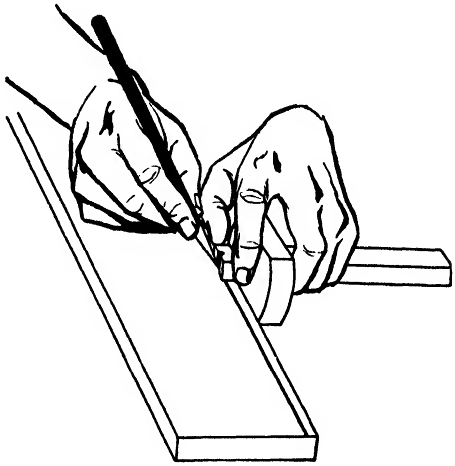


Fig. 3-57. A good way to mark a chamfer. Hold the pencil point in a small notch filed in the end of the beam of a marking gage.

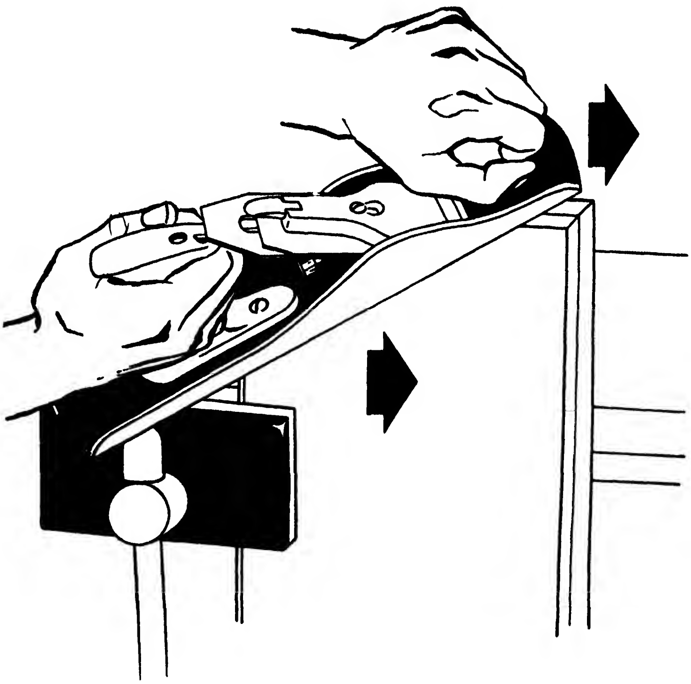


Fig. 3-58. In planing chamfers around a board, plane the edges first and the ends last. In planing end chamfers, hold the plane at an angle and push it parallel to the end. This gives an oblique cutting action.

plane the chamfers across the ends last. This avoids splintering when planing across the end grain. In planing the side chamfers, hold the plane parallel to the side or edge. In planing the end chamfers, however, hold the plane at about 45 deg to the end (see Fig. 3-58), but push it parallel to the end—not in the direction the plane points. This gives an oblique cutting action and makes the plane cut better on the end grain. (Be sure to keep the plane sharp and set shallow when planing end grain.)

As a chamfer nears completion, work carefully, and try to reach both lines on the last cut. A chamfer should be straight and true, not rounded. It may be tested by sighting and careful observation, or with a straightedge as in testing a true surface (see page 70).

Using different types of planes The *jack plane*, which is about 14 in. long, is a general-purpose plane. There are other kinds of planes especially adapted to certain kinds of work.

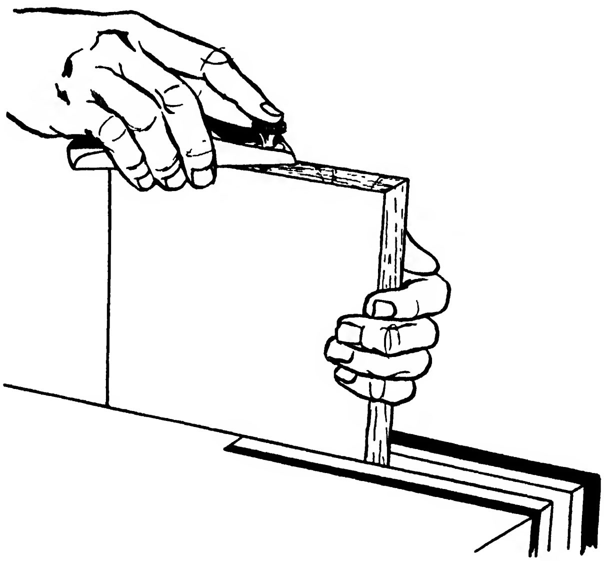


Fig. 3-59. The block plane is a very good tool for planing end grain.

The *smooth plane* is about 6 to 10 in. long and, as its name implies, is used for smoothing boards. Being short, it can follow into slight depressions in a board better than the longer planes. The smooth plane is normally used after the main straightening of the surface has been done with a jack plane. The smooth plane is sometimes selected for

the farm shop when only one plane can be bought, although the jack plane is usually preferred as a general-purpose tool.

The *jointer plane* is 22 to 24 in. long and is used primarily for straightening the edges of long pieces.

The *block plane* is a small plane about 6 in. long. It is used mostly for planing across end grain and for planing small pieces where it is not convenient to hold them in a vise. The plane, being small, can be used with one hand while the other hand holds the work. The plane bit is mounted in the body of the plane at a much lower angle than in the standard or jack plane. This makes it better for cutting across end grain (see Fig. 3-59).

Scraping wood surfaces The wood scraper is a thin, flat piece of steel with fine scraping burrs turned on its edges. The scraper is used after planing and before sandpapering. When properly sharpened it will take off a very fine, silky shaving, leaving a much smoother

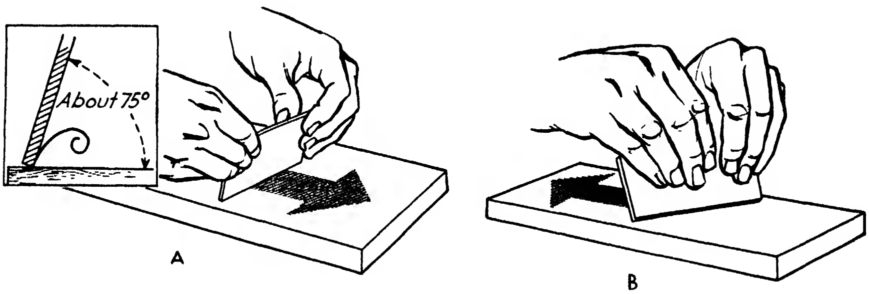


Fig. 3-60. Spring the wood scraper to a slight curve and push it, as at A, or pull it, as at B, with one end slightly ahead of the other. Keep it sharp. Dust instead of shavings indicates a dull scraper.

surface than would be possible with a plane. It is also valuable in smoothing wood that would be difficult to plane on account of irregular or gnarly grain. Scraping with a dull scraper is exceedingly slow, tedious, and discouraging work. Only an inexperienced or poor workman would try to use a dull scraper. (See Chap. 7, "Sharpening and Fitting Tools," pages 220 to 222, for instructions on sharpening scrapers.)

To use a scraper, hold it at an angle of about 75 deg to the surface of the wood and push or pull it along with one end slightly ahead of the other (see Fig. 3-60). Hold the scraper firmly and keep it sprung to a slight curve. Stop and reburnish the edge (see page 220) as often as required to keep it sharp.

Sandpapering unfinished wood surfaces Do not use sandpaper until all work with cutting tools and scrapers is finished. The beginner usually wants to use sandpaper before he should. There is generally no advantage in using sandpaper on wood that has not previously been planed or scraped. It is practically impossible to remove the planer marks (small hollows and ridges) left by the mill planer by hand sandpapering. In fact, sandpapering such surfaces generally magnifies the mill marks and actually detracts from the appearance, rather than improving it.

Select a grade of sandpaper suitable to the kind of work to be done,

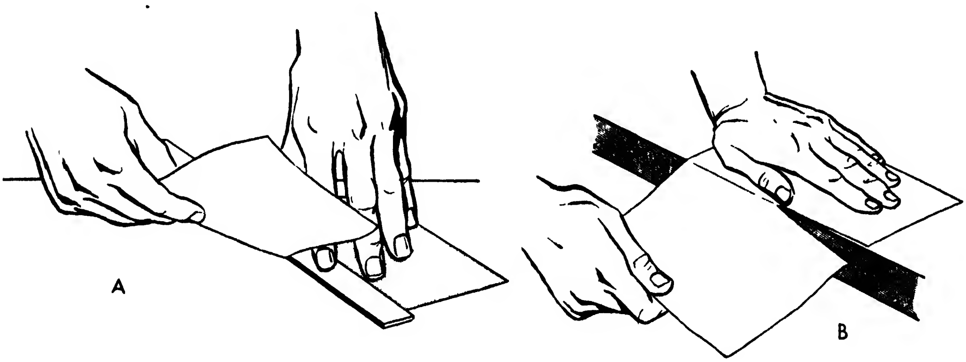


Fig. 3-61. For economy, tear sheets of sandpaper into four quarters by creasing and then tearing along the sharp edge of a rule, as at *A*, or over the edge of the bench, as at *B*.

using coarser grades for rougher surfaces or the first sanding and finer grades for the final sanding. The commonly used grades of sandpaper range from No. 00 (fine) to No. 2 (coarse). Usually No. ½ or No. 1 is satisfactory for the first or course sanding on wood, and No. 0 for the final or finish sanding.

For ordinary use, tear a sheet of sandpaper into four quarters by creasing it firmly and then tearing over the sharp edge of a rule or the edge of the bench (see Fig. 3-61). Wrap one of the small pieces part way around a flat block. For economy, the block should be of such a size that the paper will come only part way up on each edge and not around on top.

Always sandpaper back and forth *with the grain* (see Fig. 3-62), and never with a circular motion or across the grain, as this would roughen and scratch the work instead of smoothing it. Keep the block flat against the surface, particularly on narrow surfaces, and be careful

not to round the edges. If desired, to prevent splintering, a sharp edge, or arris, may be removed by running a plane over it lightly before sanding, or by running the sandpaper block over it carefully once or twice after the other sandpapering is finished.

Use only moderate pressure on the sandpaper block. Too much pressure may cause the paper to wrinkle or tear. Keep the sandpaper free of dust by knocking and shaking it out frequently.

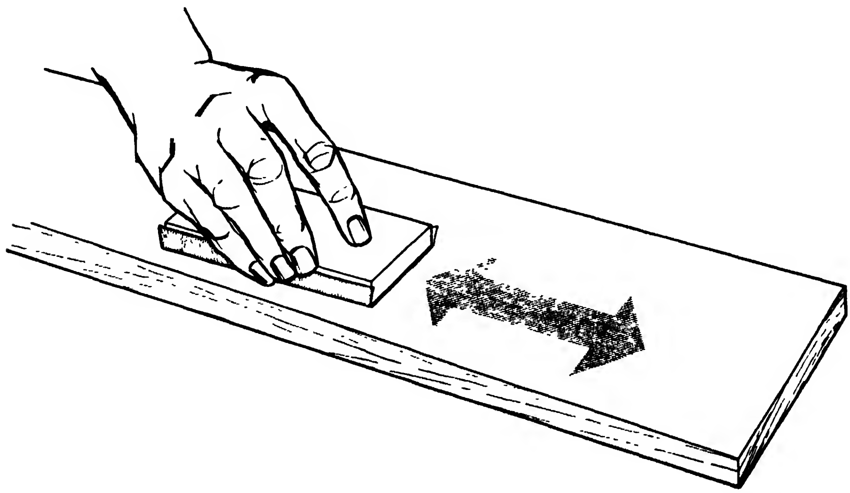


Fig. 3-62. To sandpaper flat pieces, wrap the sandpaper part way around a flat block. Always sand back and forth with the grain—never across it.

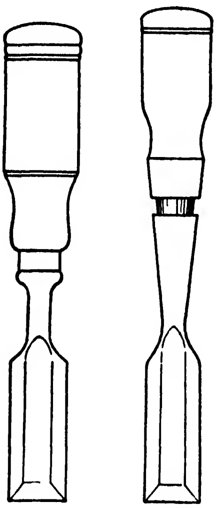
Sandpapering round and irregular surfaces For sandpapering inside or concave curved surfaces, the sandpaper may be wrapped around a round rod or stick. For very irregular work, use smaller pieces—about half of a quarter sheet—with the fingers or hand only and without a block.

5. CUTTING WITH WOOD CHISELS

Choosing wood chisels Wood chisels are made in various widths of blade, ranging from ⅛ to 2 in. They are also made in different lengths of blade, the longer ones being known as *firmer chisels,* the medium-length ones as *pocket chisels,* and the shorter ones as *butt chisels.* Wood chisels may also be classified as socket type or tang type, according to the method of attaching the handle. The socket type has a socket on the driving end into which the handle fits. The tang type has a steel

tang or shank which fits up inside the handle. Most tang-type chisels have plastic handles, while socket chisels commonly have wooden handles. A set of four medium weight butt chisels, of either the socket or the tang type, ranging in size from ¼ to 1 in., would meet the needs of most farm shopwork.

Keeping chisels sharp The first requirement for good work with a chisel is to keep it very sharp. A dull chisel not only requires extra effort to force it through the wood, but, what is more serious, it can-



A B

Fig. 3-63. Types of wood chisels: *A*, tang type; *B*, socket type.

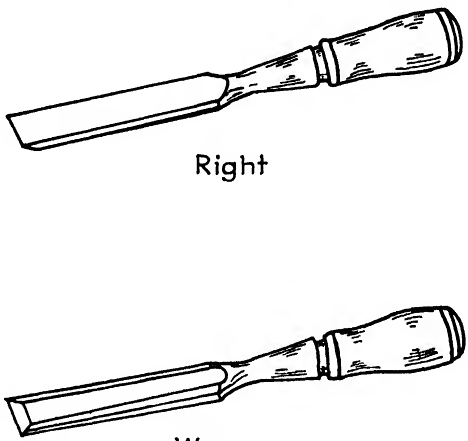


Fig. 3-64. When laying a chisel on the bench, always place the cutting edge up (bevel side down). This prevents dulling the edge.

not be easily guided and controlled. Consequently, rough, inaccurate work is almost certain to result with a dull chisel.

The chisel is very easily sharpened (see Chap. 7, "Sharpening and Fitting Tools," page 213). Whenever it becomes dull, stop and sharpen it. The time required will soon be gained back in faster and better work with the sharpened tool.

In order to prevent dulling the chisel, do not allow the cutting edge to touch other tools or pieces of metal or even the bench top. *Always lay the chisel on the bench with the bevel side down*—not up (see Fig. 3-64).

Chiseling with the grain In chiseling with the grain, as on the surface or edge of a board, observe the following points:

1. Always cut with the grain, as in planing, to avoid splitting or splintering.
2. Fasten the work in a vise whenever possible, so as to leave both hands free to use the chisel.

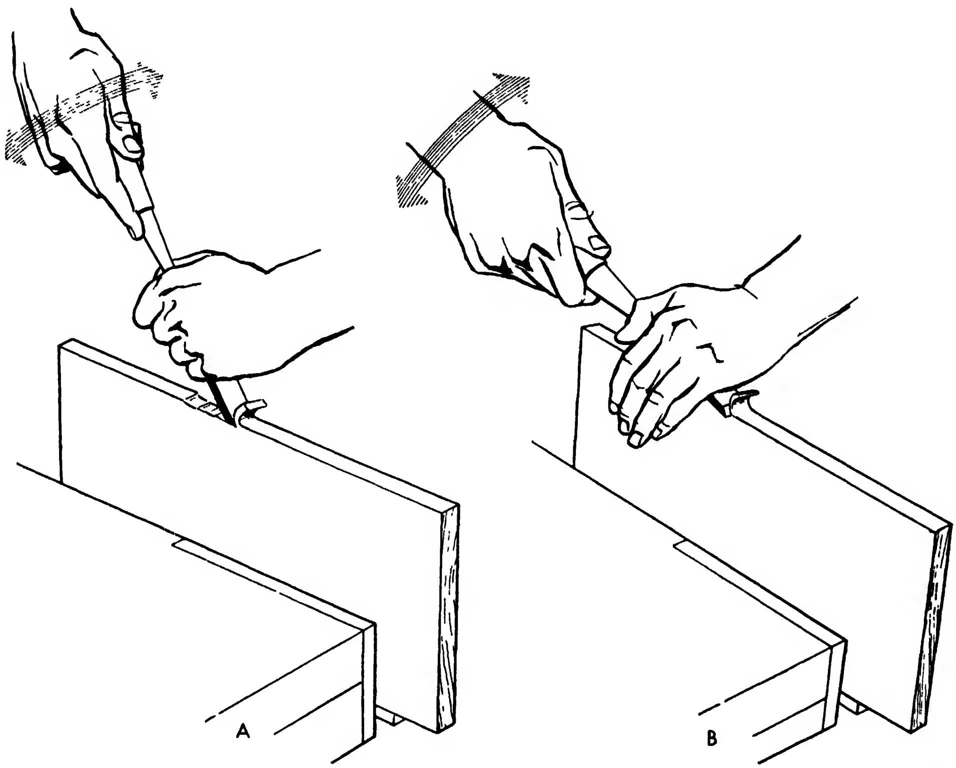


Fig. 3-65. Chiseling with the grain. Use the chisel with the bevel down, as at *A*, for deep roughing cuts, and with the bevel up, as at *B*, for light finishing cuts. Move the handle from side to side slowly as the chisel is pushed forward in order to give an oblique cutting action.

3. Always push the chisel from you, *keeping both hands behind the cutting edge.*
4. Use the left hand to guide the chisel and the right hand to push the handle forward.
5. Use the chisel with the bevel down for roughing cuts and with the bevel up for fine paring or finishing cuts. (see Fig. 3-65).
6. Hold the handle slightly to one side, or move it back and forth

slightly, as the chisel is pushed forward. This gives a sliding or oblique cutting action, which makes the chisel cut better and easier.

Chiseling across a board This kind of work is done mostly in making notches, gains, or dadoes (see pages 87 to 90). In chiseling across the grain, observe the following points:

1. Grasp the blade of the chisel between the thumb and the first two fingers of the left hand, to guide it and to act as a brake, while the pushing is done with the right hand (see Fig. 3-66*A*).
2. Do not cut all the way across a board from one side, but cut part away from one edge and part away from the other to avoid splintering.
3. Move the handle from side to side slightly as the chisel is pushed forward to give a sliding or oblique cutting action.
4. Cut with the bevel side up, raising the handle just enough to make the chisel cut. In chiseling across wide boards, however, where the chisel cannot reach the middle of the board, work with the bevel side down (see Fig. 3-66*C*).

Chiseling across end grain Chiseling across end grain is difficult work. By careful marking and sawing, however, chiseling of end grain can be kept to a minimum and sometimes eliminated altogether. In chiseling end grain, observe the following points:

1. If much waste is to be removed, take a roughing cut first, leaving about $\frac{1}{16}$ in. to be removed with a finishing cut.
2. Start on the near edge of the board, and push forward at an angle and downward (see Fig. 3-67). As the stroke proceeds, straighten the handle up until it is about vertical at the end of the stroke.
3. Guide the chisel with the left hand, and apply force with the right.
4. Use about half the width of the chisel for cutting on each new stroke. Keep the back half of the blade flat against the surface left by the previous stroke. Thus the work of cutting is made easier, and the line of cutting is more easily kept straight.
5. If the chisel is to cut entirely through or across a piece, place the work on a cutting board or piece of scrap lumber to keep the chisel from cutting into the bench, thus marring its surface and possibly dulling the chisel.

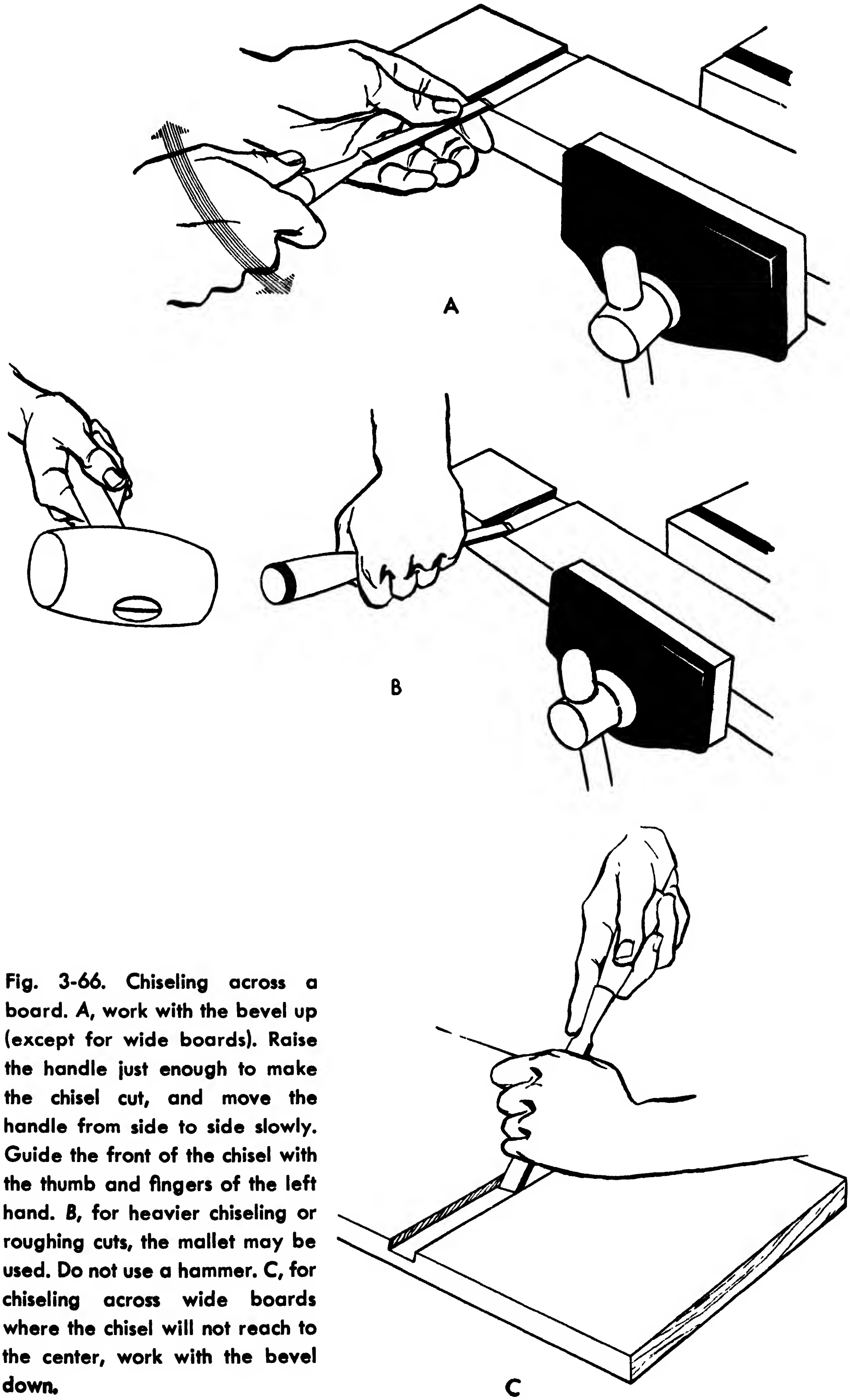


Fig. 3-66. Chiseling across a board. *A*, work with the bevel up (except for wide boards). Raise the handle just enough to make the chisel cut, and move the handle from side to side slowly. Guide the front of the chisel with the thumb and fingers of the left hand. *B*, for heavier chiseling or roughing cuts, the mallet may be used. Do not use a hammer. C, for chiseling across wide boards where the chisel will not reach to the center, work with the bevel down.

Cutting curves with the chisel Outside, or convex, curves can be cut easily by first sawing two or three straight cuts tangent to the curve, and then working with the chisel as shown in Fig. 3-68. Use the chisel with the bevel side up, the left hand holding it down and guiding it while the right hand pushes forward and moves the handle back and forth sidewise slightly at the same time.

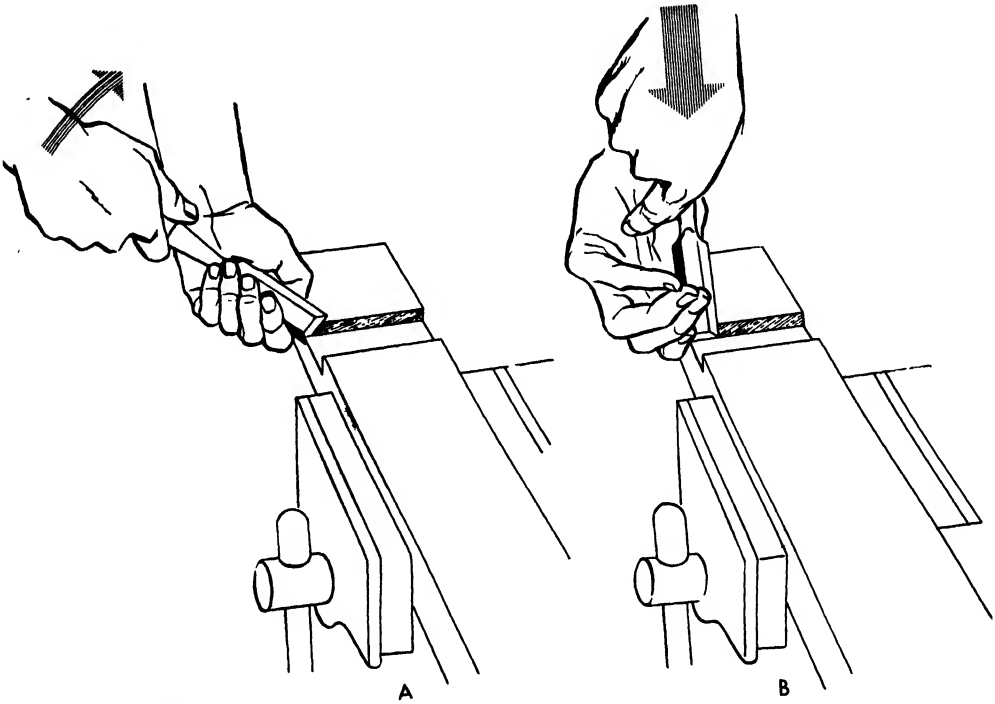


Fig. 3-67. Chiseling down across end grain. Guide the chisel with the left hand pushing forward and downward at the start, and gradually raise the handle. *A*, beginning a stroke; *B*, finishing a stroke.

The chisel is also a good tool for finishing inside, or concave, curves (see Fig. 3-69). For such work, use the chisel with the bevel side down. Guide the chisel with the left hand, while the right hand pushes down and pulls backward at the same time.

Using the mallet Use a mallet to drive the chisel where considerable force is required, as in making deep rough cuts. Never use a steel hammer, because this would soon ruin the chisel handle. A series of light taps with a mallet is better than heavy blows, because the chisel can thus be better controlled.

Paring chamfers The chisel may be used satisfactorily in paring chamfers, either with the grain or across end grain. In making chamfers, keep the bevel side of the chisel up and the flat side down. As the chisel is pushed forward, hold the handle slightly to one side, or move it from side to side, in order to give a sliding or oblique cutting action (see

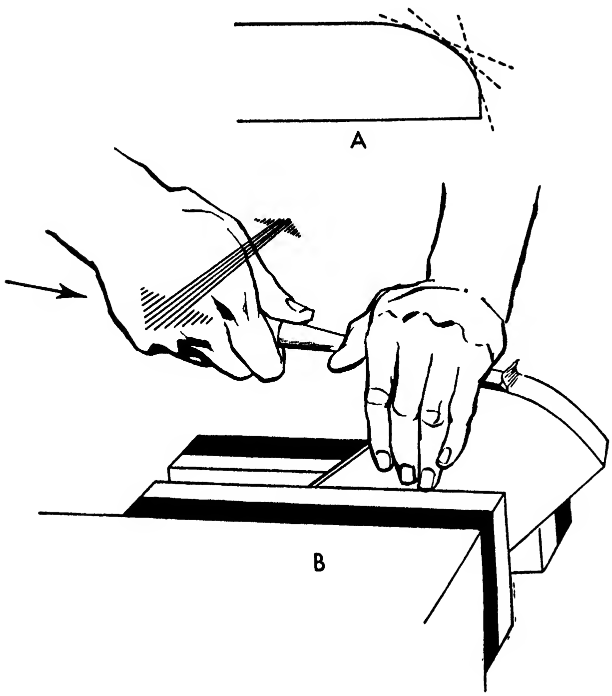


Fig. 3-68. An easy method of cutting outside, or convex, curves. A, first saw two or three lines tangent to the curve. *B*, then finish with the chisel, moving the handle from side to side while pushing it forward.

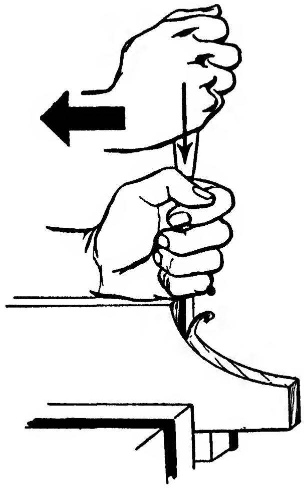


Fig. 3-69. A good method of finishing inside curves. Use the chisel bevel side down. With the right hand, push down and pull back at the same time.

Fig. 3-70). To prevent splintering when cutting end chamfers, work part way from one edge of the board and part way from the other.

Making a dado A dado is a groove that runs across a board to receive the end or edge of another board. Dadoes are commonly made in shelving and in cabinetwork.

The first step in making a dado is to mark it out accurately for depth and for width—the same as the thickness of the piece that is to fit into the dado. The piece itself may be used to mark the width of the dado by superposition (see Fig. 3-71). Use a square to ensure

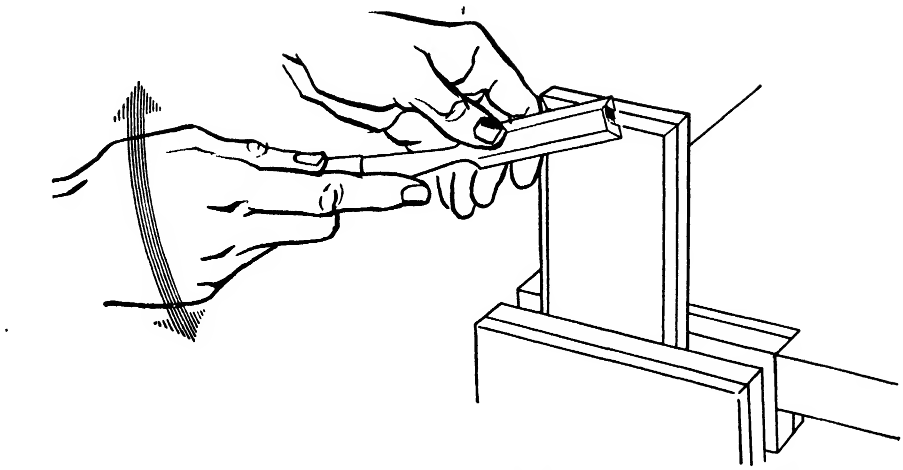


Fig. 3-70. Chamfers are easily made by paring with a chisel.

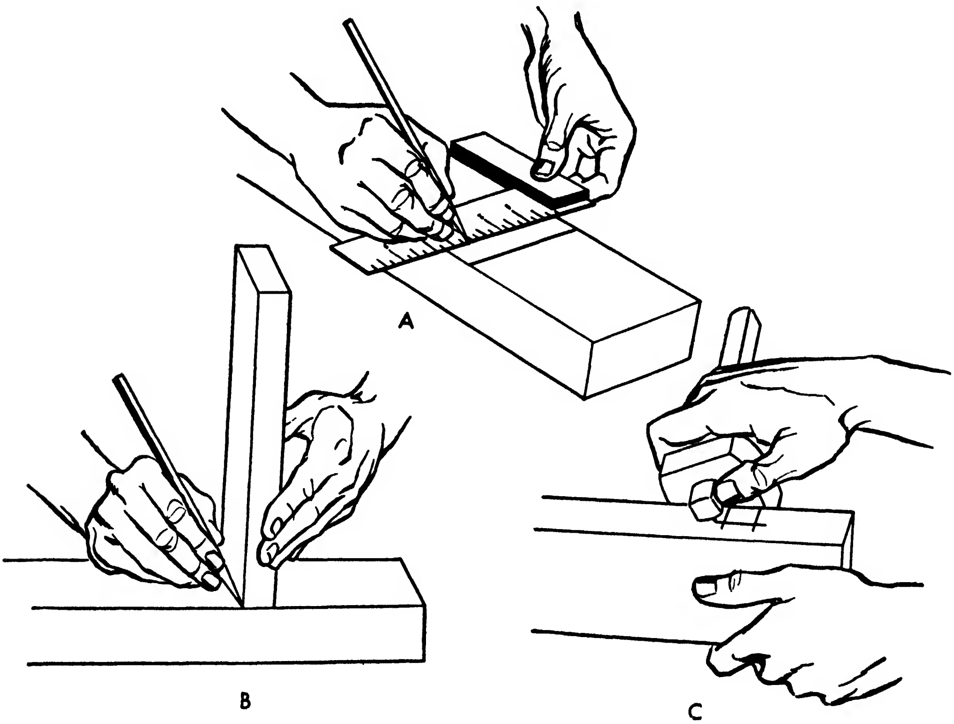


Fig. 3-71. The first step in making a dado is to mark it out accurately. *A*, marking the width with a square; *B*, marking the width by superposition; C, marking the depth with a marking gage.

marking the dado square with the edges of the board. A knife is best for marking, although a sharp pencil can be used. The depth of the dado is easily marked on the edges of the board with a marking gage (see Fig. 3-71*C*).

After the dado is accurately marked out, saw just inside the lines in the waste material. Be careful not to saw too deep. To do a good job, a straight square-edged block may be clamped in place temporarily to guide the saw (see Fig. 3-72). In making a wide dado, saw an extra kerf or two in the waste to facilitate its removal with the chisel. Then chisel out the waste, working carefully to depth and observing the suggestions for chiseling across a board as listed on page 84.

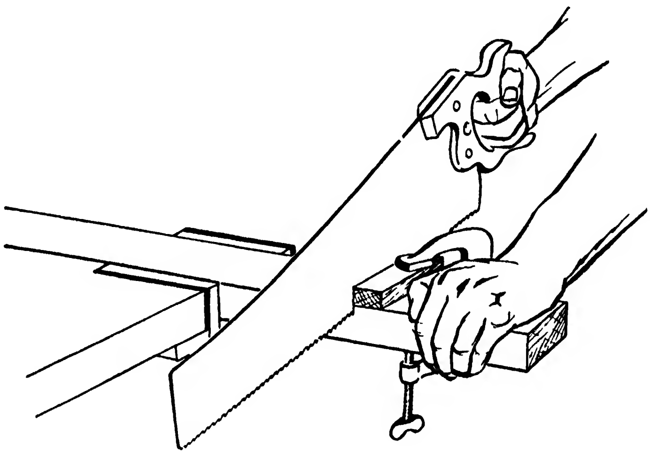


Fig. 3-72. A good way to saw the sides of a dado accurately. Clamp a straight-edged block in place to guide the saw. Thus little or no chiseling of end grain will be required. An extra saw cut or two between the sides of a dado will facilitate chiseling out the waste.

If the sawing has been done carefully and accurately, no paring of the sides of the dado will be required. If the sawing has not been done accurately to the lines, however, the sides of the dado may be finished to width by vertical paring with a chisel (see Fig. 3-67), or by filing or sandpapering.

Gaining It is frequently desirable to gain, or notch, into the edge of a piece in order to fasten a second piece securely. Typical examples are fastening the lower crosspieces to the legs of a workbench or table and fastening the steps to the side rails of a ladder.

To make a gain, first mark it out accurately to the exact width and depth, using a knife or sharp pencil and a square and possibly a mark-

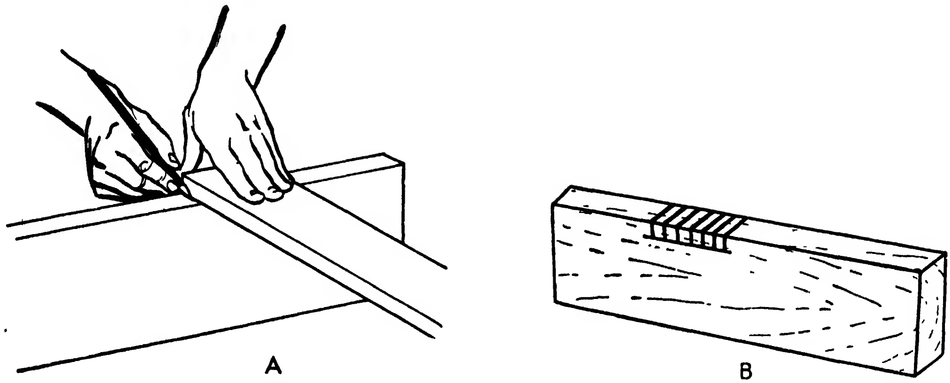


Fig. 3-73. Gaining in. *A*, marking for a gain by superposition; *B*, making several saw cuts lessens the work of chiseling out waste.

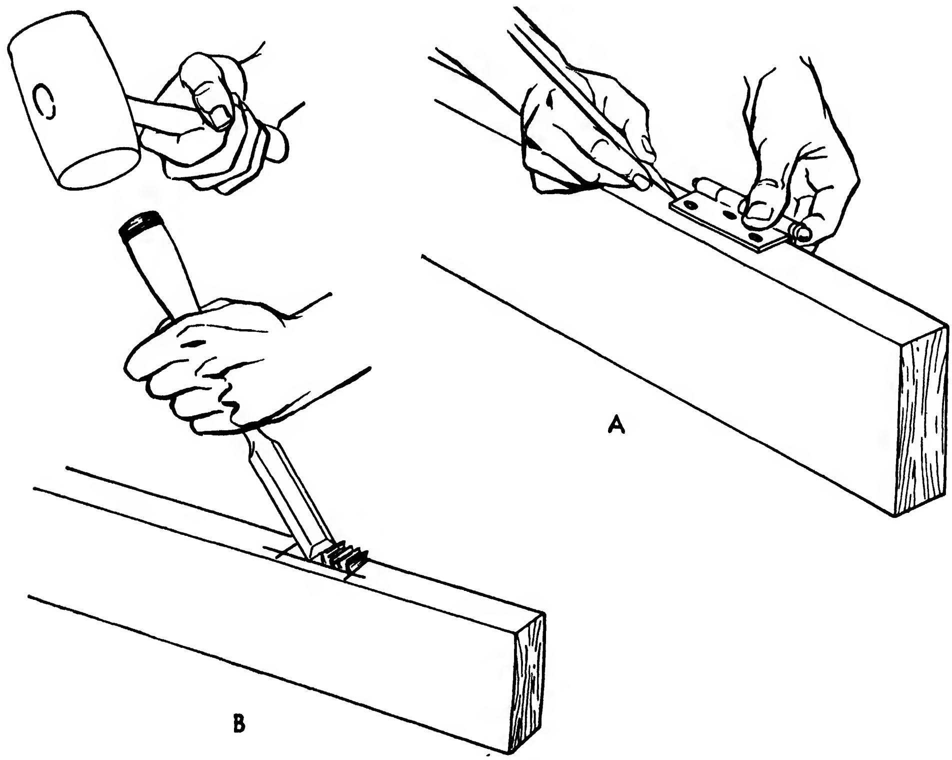


Fig. 3-74. Attaching a butt hinge. *A*, marking for the gain with a sharp pencil. Some preter a sharp knife instead of a pencil. *B*, chiseling out the gain.

ing gage. Then saw accurately and chisel out the waste in a manner similar to that described for dadoes. The chiseling will be easier if several saw kerfs are first made in the waste as shown in Fig. 3-73*B*.

Marking for a gain may often be simplified by using the piece that is to fit into the gain and marking by superposition (see Fig. 3-73*A*).

Attaching butt hinges To attach a butt hinge, first put it in place and mark around it carefully with a sharp pencil or knife (see Fig. 3-74*A*). Then remove the hinge and gage a line on the side of the piece to indicate the depth the hinge is to be set or gained in. Then carefully cut out the waste with a chisel (see Fig. 3-74*B*), trying the hinge in place for fit as the work nears completion.

After the gain is finished, fasten the hinge in place with screws, first making holes for the screws with an awl or a drill.

Rabbeting A rabbet is a groove cut in the edge or end of a piece to receive a second piece like a panel. Rabbeting is commonly done in making frames to hold glass and frequently, also, in constructing drawers and other cabinetwork. A rabbet may be made with a chisel if it is first accurately marked out and the workman is careful. Marking is best done with a marking gage. It is much easier to cut a rabbet with a power saw or jointer, or with a special grooving or rabbeting plane, if such tools are available.

6. BORING AND DRILLING HOLES IN WOOD

Figure 3-75 shows a typical carpenter's brace that is used for turning such tools as wood auger bits, twist drills, screw-driver bits, countersinks, and reamers. Braces are made either with or without the ratchet device.

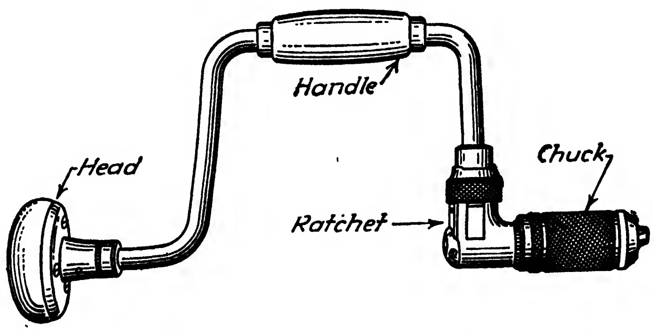


Fig. 3-75. A carpenter's brace.

A ratchet makes it possible to bore holes in close quarters where the handle cannot be turned all the way around. This type is also more convenient in boring in hardwood and in driving screws with a screw-driver bit. For such work, it is frequently easier and better to turn the brace by part turns rather than by full continuous turns.

The size of a brace is designated by its sweep, or the diameter of the circle through which the handle swings. A brace with an 8-in. sweep is suitable for average work.

Figure 3-76 shows an auger bit, the most common tool for boring holes in wood. The size of an auger bit is designated by a number stamped on the shank, the number being the size of the bit in sixteenths of an inch. Thus a bit marked 7 bores a hole 7/16 in. in diameter, a bit marked 11 bores a hole 11/16 in., etc.

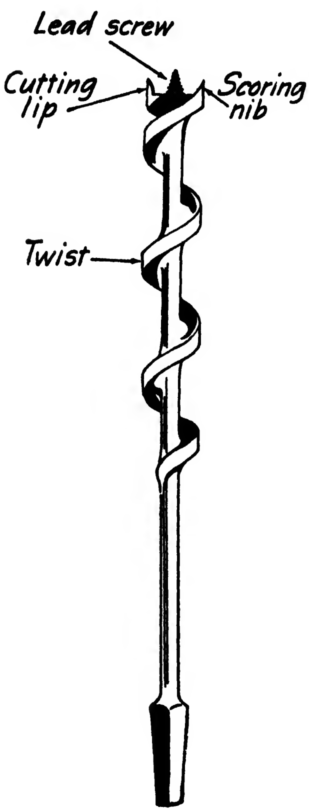


Fig. 3-76. An auger bit.

As an auger bit is turned, the lead screw guides the bit and draws the cutting parts into the wood, so that only moderate pressure is required on the brace. The spurs or scoring nibs cut off the wood fibers, and the cutting lips cut out the waste inside the circle scored by the nibs. The twists on the bit carry the waste to the surface.

Starting the auger bit For accurate boring, first mark the location for the center of the hole, by the intersection of two cross lines, or by a small hole made with an awl or other sharp-pointed tool. Then, with one hand, guide the point of the bit carefully into place, while the other hand exerts a slight pressure on the head of the brace (see Fig. 3-77).

As the auger starts boring, be careful to keep it perpendicular to the surface (unless it is desired to bore the hole at an angle). To check to see that the auger is boring square with the surface, step back a little, steadying the brace with one hand, and sight; then move around and sight in another direction about at right angles to the first direction of sighting (see Fig. 3-78*A*). A square may also be used to see

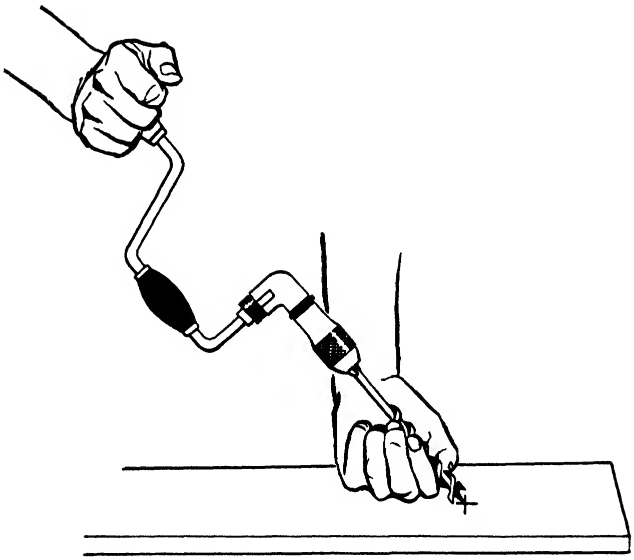


Fig. 3-77. Steadying the hand, knuckles down against the board, helps to place the point of the bit accurately.

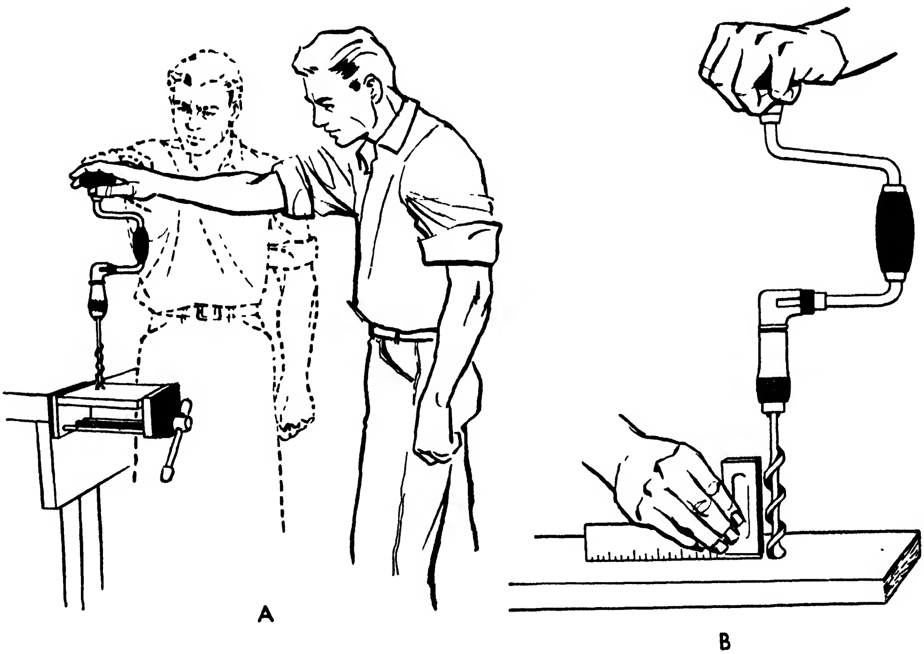


Fig. 3-78. To ensure boring straight, sight from two directions, as at *A*; or check with a square, as at *B*.

if the bit is going straight (see Fig. 3-78*B*). It is better for a learner not to depend too much on the square, however, but to develop his ability in sighting. Leaning the top of the brace slightly one way or another will change the direction of boring.

Boring through If a hole is to be bored entirely through a board, bore until the point of the bit can be felt on the other side of the board (see Fig. 3-79). Then turn the board over and bore from that side. This prevents splintering around the edge of the hole.

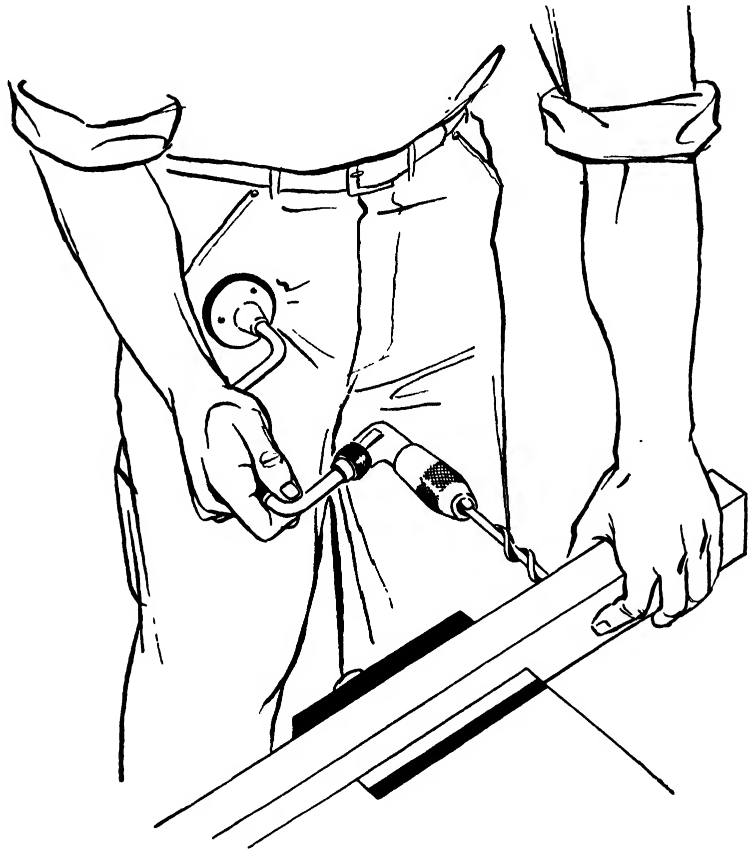


Fig. 3-79. To prevent splintering when boring a hole, stop when the point of the bit can be felt and finish by boring back through from the other side.

Another method that may be used, especially on pieces that can be held in a vise, is to clamp a block of scrap wood behind the piece through which the hole is to be bored. The boring can then be done from one side without danger of splintering.

Boring to depth A good way to bore a hole to a definite depth is as follows: Stop turning as soon as the cutting lips touch the wood, and measure the distance from the end of the chuck to the surface of the piece being bored. Then bore until the measurement on the rule is decreased by an amount equal to the desired depth of hole (see Fig. 3-80*A* and *B*).

If a number of holes are to be bored to the same depth, considerable time may be saved by cutting a block to the correct length and using it as a gage as shown in Fig. 3-80*C*, or by boring a hole through

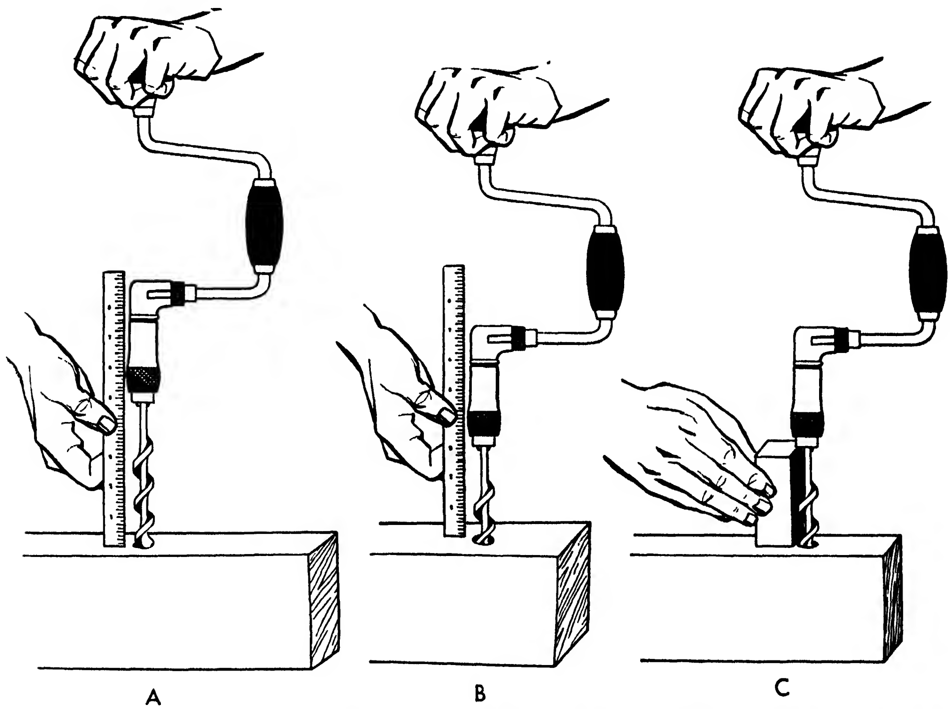


Fig. 3-80. In order to bore to an exact depth, measure the distance from the surface to the chuck just as the lips start cutting, as at *A*; then bore until the measurement is decreased an amount equal to the desired depth, as at *B*. When several holes are to be bored the same depth, a block may be cut to fit under the chuck and used as a gage, as at C.

the block and using it on the auger in a manner similar to that shown in Fig. 3-85).

Counterboring Counterboring is making a hole larger at the mouth than deeper down. Where pieces of wood are to be fastened together with bolts or some kinds of screws, counterboring, is frequently done to sink the boltheads or screwheads below the surface (see Fig. 3-103).

To make a counterbored hole, first bore with a bit of a diameter suitable for the counterbore. After the desired depth of counterbore is reached, finish with a smaller bit. Do not bore the small hole first, for then there will be no center to guide the large bit.

Preventing splitting while boring Boring large holes in thin or narrow pieces sometimes causes splitting, owing to the wedging action of the lead screw on the bit. Such splitting can be avoided by drilling through first with a small twist drill, or by clamping the piece in a vise with the vise jaws against the edges—not the sides—of the piece.

Drilling with twist drills These drills (Fig. 3-81*B* and *C*) can be used for drilling holes in either wood or metal, and their use is recom-

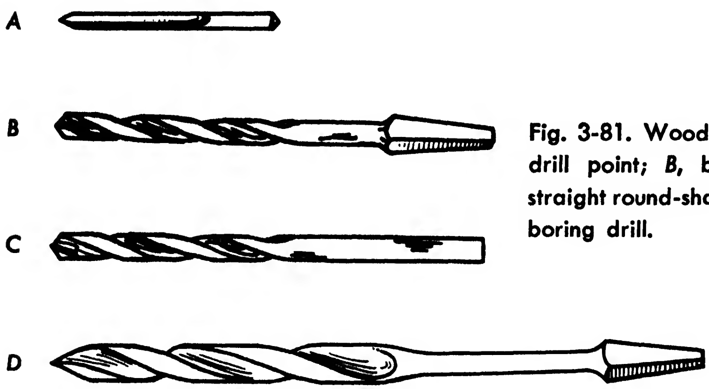


Fig. 3-81. Wood-drilling bits: *A*, wood-drill point; *B*, bit-stock twist drill; *C*, straight round-shank twist drill; *D*, wood-boring drill.

mended where there is danger of striking a nail or other piece of metal that would dull an auger bit. The smaller sizes of twist drills are very good for drilling holes to receive wood screws.

To drill a hole in wood with a twist drill or other blunt-pointed drill, start the drill in a mark or depression made with an awl or a nail. Otherwise, the point may "drift" from the proper location when the drill starts turning, and the hole will not be drilled exactly where it is wanted.

In drilling holes in wood with a twist drill, remove the drill frequently to clean the cuttings from the twists or flutes. This prevents overheating the drill and also speeds up the work of drilling. See Chap. 7, "Sharpening and Fitting Tools," pages 224 to 230, for suggestions on sharpening twist drills.

Wood-boring drills Figure 3-81*D* shows a wood-boring drill. This is similar to a twist drill, but is usually longer and has a sharper point.

Wood-drill points Figure 3-81*A* shows a wood-drill point, used for drilling small holes in wood. Wood-drill points are very much like small twist drills except that they are made of softer steel and have straight instead of spiral grooves or flutes. They are commonly sold in sets ranging in size from $\frac{1}{16}$ to $\frac{11}{64}$ in. They are used in hand drills or automatic push-type drills.

Using the small electric drill A small portable electric drill which will take drills of $\frac{1}{4}$-in. size and under is one of the most useful tools for the shop. It can be used for drilling holes in metal as well as wood and, with suitable attachments, for many other jobs. While drilling small holes with a hand drill is not tiring or difficult, such work can be done much faster and more easily with an electric drill.

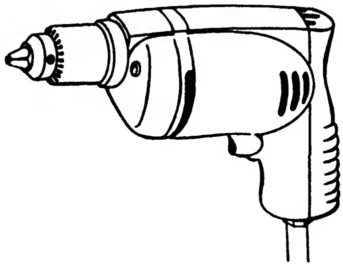


Fig. 3-82. A small-size electric drill is a most useful tool for the shop.

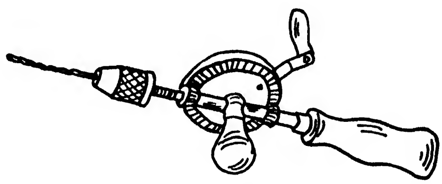


Fig. 3-83. The hand drill is a very useful tool for drilling small holes in either wood or metal.

To drill holes with an electric drill, simply select a drill bit of suitable size, mount it in the chuck, and pull the switch, which, on most drills, is of the trigger type.

Using the hand drill The hand drill (Fig. 3-83) is one of the most useful tools for drilling small holes either in wood or in metal. It is small and light and is much faster and more convenient than the carpenter's brace. Also, there is less danger of breaking small drill bits when using them in the hand drill.

In using a hand drill, hold it straight and steady, push with an even pressure against the handle, and turn the crank with a steady, moderate speed (see Fig. 3-84). Either too slow or too high a speed or too heavy pressure is likely to bend or break small drill bits.

Using the automatic push drill The automatic push drill (Fig. 3-86) is sometimes used for drilling small holes in wood. Pushing the handle down and letting it come back up imparts a forward and backward rotary motion to the drill bit. Drilling with the push drill is a

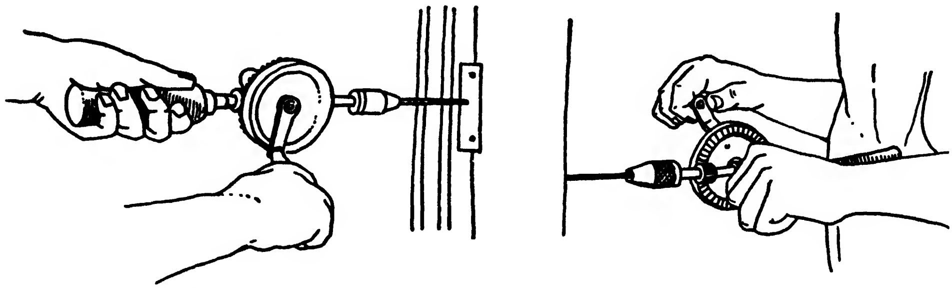


Fig. 3-84. In drilling with a hand drill, hold it straight and steady and turn with a moderate, even speed. It is sometimes more convenient to hold the drill by the side handle and lean against the end handle. (Stanley Tools)

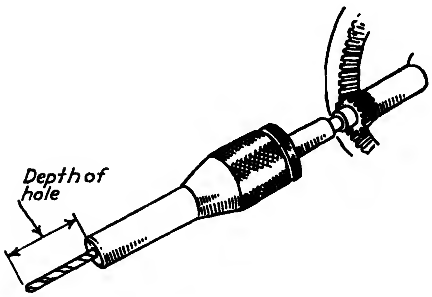


Fig. 3-85. A convenient depth gage can be made by cutting a piece of wood to the correct length, drilling a hole through it, and slipping it over the bit. (Stanley Tools)

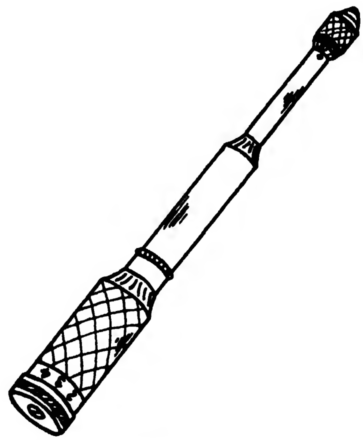


Fig. 3-86. The automatic push drill.

little slower than with the hand drill. The push drill can be operated with one hand, however, leaving the other free to hold the work.

7. FASTENING WOOD

Fastening with nails

There are two general kinds of nail hammers: *bell-face* hammers or flat or *plain-face* hammers. Bell-face hammers have striking surfaces

that are slightly round or convex, and with careful use it can drive nails up tight with their heads flush with the surface of a board, or even slightly below, without leaving hammer marks. Plain-face hammers, having flat faces, are a little easier to learn to use.

Hammers with straight claws, like those shown in Fig 3-94, are called *ripping hammers.* They are especially good for ripping off old boards.

The size of a hammer is designated by the weight of the head exclusive of the handle, the most common sizes ranging from 12 to 16 oz.

Nails are made from steel wire by special machines that receive the wire from large rolls, cut it into the desired lengths, and form the

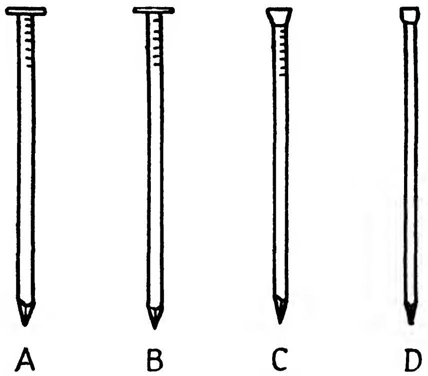


Fig. 3-87. Some of the more common kinds of nails: *A*, common nail; *B*, box nail; *C*, casing nail; *D*, finishing nail.

points and heads automatically. Various kinds of nails are used for different purposes. *Common nails* (see Fig. 3-87) are of large diameter, have large flat heads, and are most commonly used for rough carpentry work. The larger-sized common nails are called *spikes. Box nails* are similar to common nails, but are more slender. They are used on wooden boxes and crates. Since they are smaller in diameter, there is less danger of splitting. They are available either plain or cement coated to give greater holding power. *Casing nails* are of the same size as box nails, but have small tapered heads instead of flat heads. They are used where large nailheads would be objectionable, as in cabinetwork and in blind nailing of tongue-and-groove flooring. *Finishing nails* are somewhat more slender than casing and box nails and have small heads. They are used mainly in inside trim or finish carpentry and in cabinetwork. The heads are driven flush, or set below the surface with a nail set. Other commonly used nails are lathing nails, shingle nails, roofing nails, fence nails, and plasterboard nails, used for

the special purposes indicated by their names. Very small nails called *brads* are also available for fastening small pieces.

The size of nails is designated by the term *penny,* 2-penny nails being small, and 4-, 6-, and 8-penny nails being larger. All kinds of nails of the same penny size are of the same length. For example, 8-penny nails are all 2½ in. long; all 6-penny nails, 2 in. long; etc. All nails of a given penny size are not of the same diameter, however. As indicated in the preceding paragraph, common nails are of larger diameter, box nails and casing nails somewhat smaller, and finishing nails still smaller in diameter.

Driving nails To start a nail, hold it steady with the thumb and fingers of one hand, and strike one or two light blows with the hammer (see Fig. 3-88). After the nail is well started, drive it up tight with firm, well-directed blows. Hold the hammer handle near the end, and strike squarely on top of the nailhead. For light driving, use mostly wrist motion; for heavier hammering, use wrist motion and elbow motion; and for very heavy hammering, use shoulder action, as well as wrist and elbow motion.

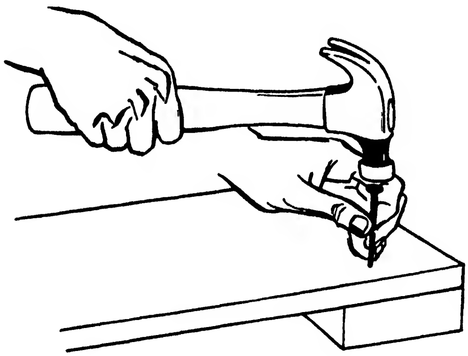


Fig. 3-88. Steady the nail with one hand while striking one or two light taps of the hammer with the other. Then follow with firm, well-directed blows. Grasp the hammer handle near the end.

In driving a nail flush with the surface of a board, make the final blow with care so as not to leave a hammer mark on the surface.

Keep the striking face of the hammer clean to prevent it from slipping off the nailhead.

Preventing splitting If there is danger of splitting a board when a nail is driven, a smaller nail should be used, as a smaller nail will have more holding power than a larger one that splits the board. Some nails have chisel-shaped points, owing to the method of manufacture. Drive such nails with the long way of the point across the grain, so that they

cut the fibers of the wood instead of wedging them apart and causing splitting. Splitting may be prevented in thin boards and where short nails are used by cutting the nails off square or chisel-shaped with nippers or pliers.

Pulling nails To pull a nail, slip the claws of the hammer under the nailhead, and pull up and back on the hammer handle. If the nail is not pulled out by the time the handle is about straight up, stop and place a block under the head of the hammer, and then proceed (see Fig. 3-89). Pulling the hammer handle too far back may over-

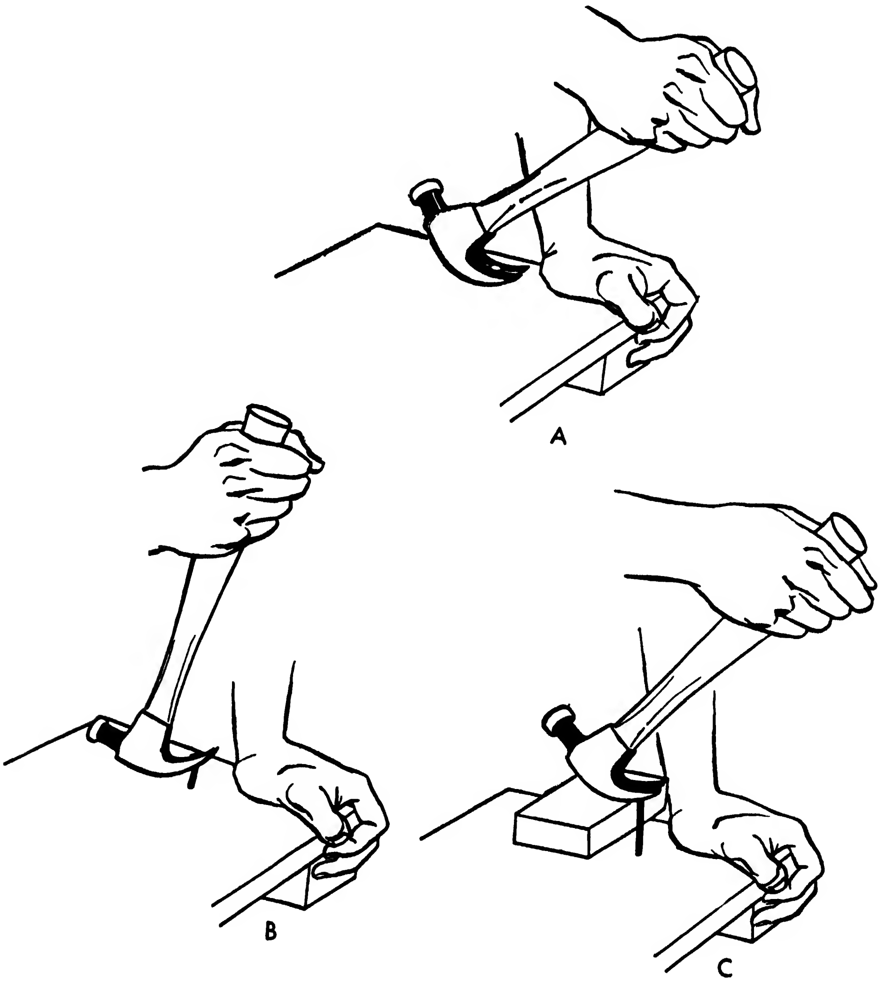


Fig. 3-89. Steps in pulling a nail. A, slip the claws under the nailhead; B, pull until the hammer handle is nearly vertical; and C, put a block under the hammer head to increase the leverage and relieve the strain on the handle.

strain it, or possibly break it. The block increases the leverage and reduces the strain on the hammer handle.

If the nailhead is down in the wood so far that the claws cannot be slipped under it, a pair of pincers may be used to start pulling the nail, or a small cold chisel and hammer may be used. Such methods, however, are almost certain to mar the wood.

Locating nails in nailed joints The strength of a nailed joint depends largely upon the distribution and location of the nails. Where possible, stagger the nails and do not drive them too close together or in line with the grain. Examples of right and wrong methods are shown in Fig. 3-90. It is always good practice to nail through a thin piece

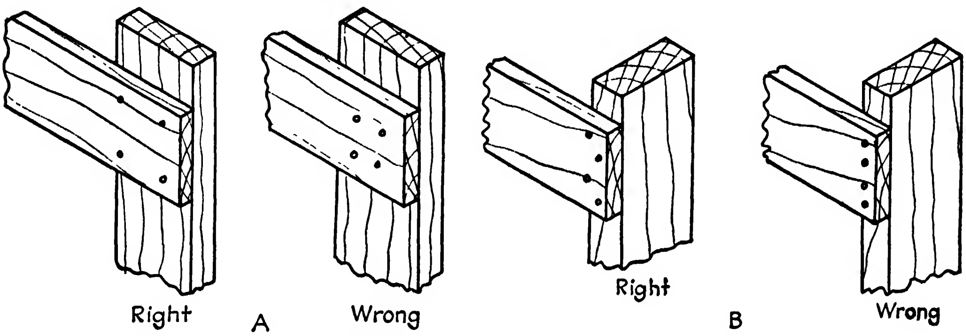


Fig. 3-90. Right and wrong methods of nailing.

into a thick one, and not through a thick one into a thin one. It is also good practice, wherever possible, to drive nails across the grain of the wood rather than into end grain (into the ends of boards). Figure 3-91 shows a well-nailed crate corner with none of the nails driven into ends of boards.

Clinching nails Nails are clinched by bending the ends that protrude after they are driven. Clinching makes nails hold better. For greatest holding power, bend the end of the nail opposite to the direction in which the head would move in case the nail should draw under load. For example, if strain on the nailed parts tends to pull the head down, then bend the point of the nail up; if the strain tends to move the head to the right, bend the point to the left (see Fig. 3-92).

Toenailing This is done to fasten a piece that butts against another (see Fig. 3-93). Good judgment must be used in selecting the point

to start the nail and the angle to drive it. The nail should get a good hold in the first piece without danger of splitting, and yet go deep enough into the second piece to ensure good holding.

Setting nails To set the head of a finishing nail or a casing nail slightly below the surface, drive it in the usual manner until the head

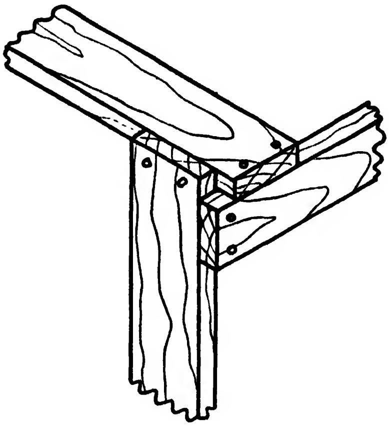


Fig. 3-91. A strong nailed corner used in crating.

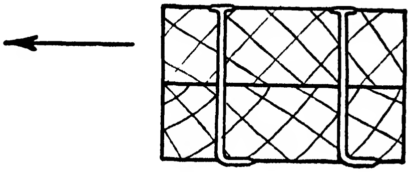


Fig. 3-92. Clinched nails. If forces tend to move the top board to the left, the points of the nails should be bent over to the right.

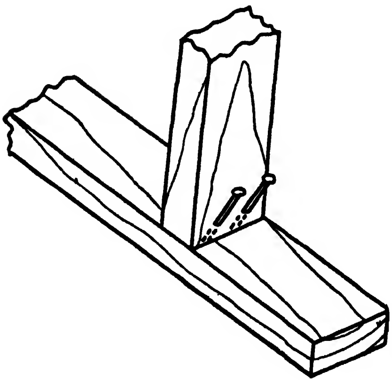


Fig. 3-93. A toenailed joint. Start the nails high enough to prevent splitting and low enough to give deep penetration into the second piece.

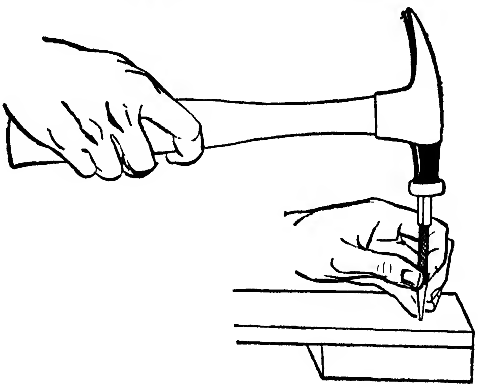


Fig. 3-94. Setting a nail. To hold the nail set in place on the nailhead, steady the hand on the board and hold the tip of the little finger against the set.

is almost, but not quite, flush. Then finish with a nail set. A nail set resembles a small punch and has a cup-shaped point. If possible, select a nail set with a cupped point slightly larger than the nailhead. Hold the set in the left hand, supporting the top part with the thumb and

first three fingers, and holding the point on the nailhead with the tip of the little finger (see Fig. 3-94). Set the nailhead about $^{1}/_{16}$ in. below the surface.

Draw nailing Where it is desired to make a tight joint between two boards, as between pieces of tongue-and-groove flooring, drive the nails at an angle with the surface, as shown in Fig. 3-95. The

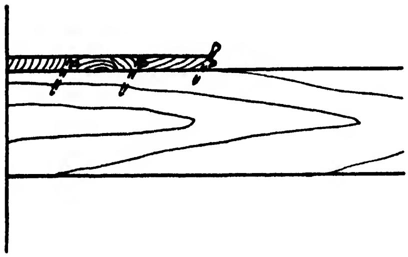


Fig. 3-95. Draw nailing. Driving the nails at an angle helps to draw the boards tightly together.

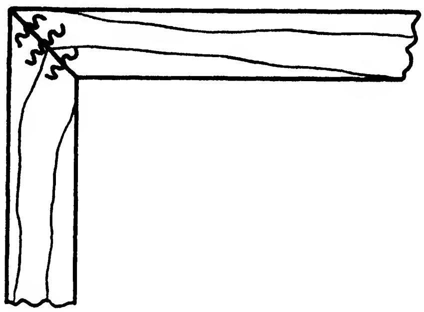


Fig. 3-96. Corrugated fasteners used to strengthen a miter joint.

nails then have a drawing effect as they are driven up, making the joint tight.

Using corrugated fasteners Corrugated fasteners can frequently be used to advantage in reinforcing joints like miter joints (see Fig. 3-96) and butt joints. They are especially good when used in end grain. In driving them, be careful to keep them straight, and do not drive one end faster than the other.

Fastening with screws

Pieces of wood can be fastened together more securely with screws than with nails. Yet pieces fastened with screws can be taken apart more easily and with less damage. Fastening with screws, if done in a systematic manner, can be done quickly and easily and with excellent results. On the other hand, if careless, slovenly methods are used, much time will be wasted, and the work will most likely be disappointing. The main points to observe are the following:

1. Select screws of suitable size and length.
2. Drill holes of the proper size and depth for the screws.
3. Use screw drivers that are in good condition and that fit the screws.

There are various kinds and sizes of screws. The *flathead* screw is most commonly used in woodwork, although *oval-head* and *round-head* screws are sometimes used, mainly for their ornamental effect.

The size of wood screws is designated by (1) the gage number, which indicates the size of the shank, and (2) their length, measured as shown in Fig. 3-97.

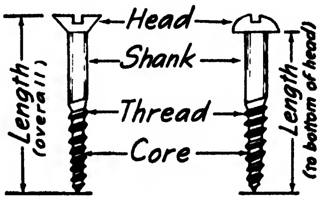


Fig. 3-97. Parts of a wood screw.

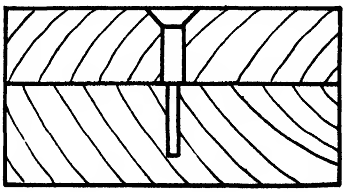
Steel screws without any special finish, designated simply as *bright,* were once commonly used in woodwork. Cadmium-plated rustproof screws are much better and are now more commonly used. Other finishes are nickel-plated and blued. Screws made of brass are also sometimes used. Brass screws are not so strong as steel screws, however, and more care must be used in driving them to prevent twisting them in two or marring the screwheads.

In ordering screws, always specify the size, kind, and finish, as 1½-in. No. 8 flathead cadmium-plated wood screws.

Using lag screws A lag screw might be described as a square-headed bolt, but pointed and with coarse threads to screw into the wood instead of fine threads to receive a nut. Lag screws are used where ordinary wood screws would not be strong enough. The size of a lag screw is designated by the diameter of the unthreaded part near the head and by the length.

Determining sizes of holes to drill for wood screws Whenever pieces of wood are to be fastened together, always drill holes as shown in Fig. 3-98. Drill the hole through the first piece the size of the

Fig. 3-98. Always drill holes to receive wood screws in fastening two pieces of wood together. Make the hole in the first piece the size of the screw shank or a little larger. Make the hole in the second piece the size of the core of the screw and drill it almost as deep as the screw will go.



shank of the screw, *or a little larger;* and drill the pilot hole in the second piece the size of the core or body of the screw under the threads, *or slightly smaller.* In the case of hardwood, or of large screws, or of screws of soft metal like brass, drill the pilot holes nearly as deep as the screws will go. In the case of softwood, or medium to small screws, drill the pilot holes about half as deep as the screws will go. When very short screws are used and the wood is soft, the pilot holes in the second piece may be made with an awl or a nail.

TABLE 3-2. Sizes of Holes to Drill for Wood Screws

Screw size	Size of first hole (shank), 32d in.	Size second hole (thread), 32d in.
2	3	2
3	4	2
4	4	2
5	4	3
6	5	3
7	5	4
8	6	4
9	6	4
10	6	5
11	7	5
12	7	5
14	8	6
16	9	7

A table like Table 3-2 may be used as a guide in selecting the proper sizes of drills for the different sizes of screws. If such a table is not at hand, it is a good plan to drill holes in scrap material and try the screws in them before drilling holes in the work. The hole through the first piece should never be so small as to require a screw driver to force the screw into it.

Locating and drilling the holes Mark the location for screw holes accurately, usually first by the intersection of cross lines, and then with a deep mark or depression made with an awl. Make the depression deep enough to keep the drill from "wandering" when it starts to turn.

Drill the holes through the first piece before marking the locations

for holes in the second piece. Then, using the first piece as a guide or template, mark the locations for holes in the second piece with an awl, a pencil, or a nail (see Fig. 3-99). Or, if the two pieces can be held in alignment in a vise or a clamp, simply drill the holes in the second piece without marking, using the holes in the first piece to guide the drill bit.

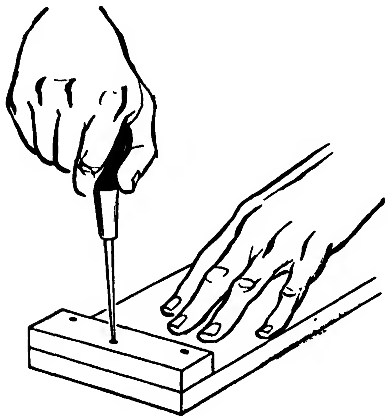


Fig. 3-99. Marking locations of drill holes in the second board by using the top one as a template for guiding the awl.

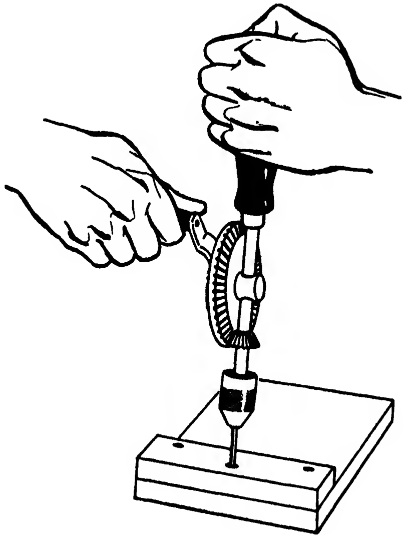
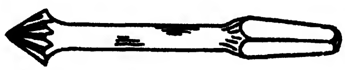


Fig. 3-100. After one or two screws are driven, the remaining pilot holes in the bottom piece are easily drilled by using the holes in the top piece to guide the drill.

Sometimes when several screws are to hold two pieces together, it is possible to drill one or two pilot holes in the second piece and set the screws in these holes to hold the pieces together. The remaining pilot holes can then be drilled easily by using the holes in the first board as guides (see Fig. 3-100).

Countersinking When flathead screws are used, always countersink the holes to allow the heads to draw down flush with the surface, or in some cases slightly below. Countersink all holes to the same depth, and be careful not to countersink them too deep. It is a common

Fig. 3-101. A common type of countersink used for countersinking flathead screws.



mistake to countersink too deep. Trying a screw upside down in a countersunk hole is a good way to test for depth (see Fig. 3-102). The *diameter* of the top of the hole should be about the same as the diameter of the top of the screwhead.

Sometimes when round-head screws are used, the holes are counterbored to sink the heads below the surface, as shown in Fig. 3-103. In

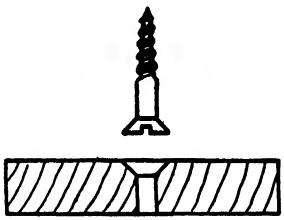


Fig. 3-102. Checking the countersunk hole for depth by trying the screw upside down in the hole.

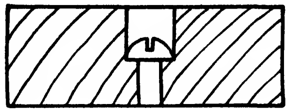


Fig. 3-103. Counterbored holes may be used to sink round-headed screws below the surface.

making a counterbored hole, be sure to bore with the large auger or bit first, and the small one last. Otherwise, it will be difficult or impossible to bore or drill the large section of the hole clean and smooth.

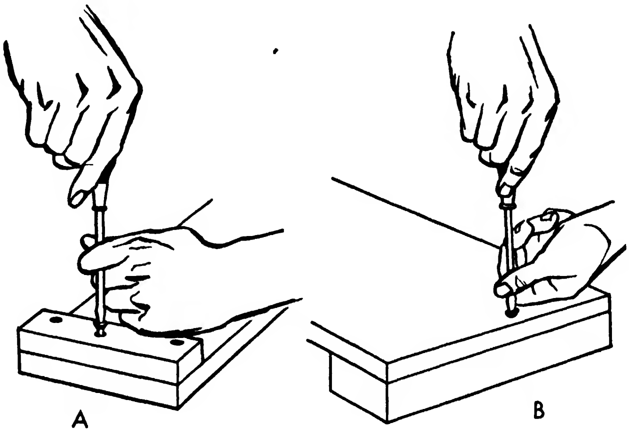
Using the screw driver First select a screw driver of suitable size. A screw driver that is too wide or too narrow may mar the work or the screwhead or both. Also there is danger of damaging a screw driver that is too small. A good mechanic keeps a set of screw drivers of different sizes and selects one that fits the screw.

Be sure that the screw-driver blade is properly shaped and in good condition. The end should fit the screw slot. The two flat faces should be straight and parallel, or slightly concave, near the tip where it fits into the screw slot. The tip should be uniform in width or thickness and square with the broad surfaces. It should never be ground or filed rounded or to a sharp edge like a knife. The shank should be straight, and the tip should be in line with the shank. (See Chap. 7, "Sharpening and Fitting Tools," page 232, on fitting screw drivers.)

In using a screw driver, grasp the handle firmly in the right hand with the palm resting on the end of the handle and the thumb and first finger extending along the handle. While the right hand gets a new grip for the next turn, use the left hand to steady the screw driver and keep it in the screw slot (see Fig. 3-104).

If the screw turns too hard, the pilot hole in the second piece

may be too small or not deep enough, or the shank hole through the first piece may be too small. The screw should be removed and the trouble determined and remedied. Otherwise, the screw may twist off or split the board, or the screw driver may slip from the screw slot and mar the work or the screwhead, or both.



A B

Fig. 3-104. Two good methods of using a screw driver. While the right hand gets a new grip on the handle for the next turn, the left hand holds the bit steady and keeps it in the screw slot.

A little soap, wax, or oil applied to the threads of the screw will make it go into the hole more easily.

Points on the care and use of screw drivers; safety rules

1. Keep the end free from grease or oil while using it.
2. Do not hold the work in the hand while tightening or loosening a screw. If the blade should slip, a bad cut might result. Hold the work in a vise or on a solid surface.
3. Never use the screw driver as a chisel.
4. Do not strike the handle with a hammer.
5. Do not use the screw driver for a pry bar.
6. Be sure the screw driver is in line with the screw.
7. Do not carry a screw driver in a pocket. The point might cause an injury.
8. Do not use a screw driver with a bent blade. Straighten it or discard it.
9. Hold the work so that if the screw driver should slip there would be no injury to the hands, face, or other parts of the body.

Using the screw-driver bit Where several screws are to be driven, particularly large screws, a screw-driver bit in a brace makes for faster and easier work (see Figs. 3-105 and 3-106*B*). Such a bit is simply a short screw driver that has a square tapered end to fit into a carpenter's brace instead of a handle. Use care with the screw-driver bit to keep it from slipping from the screw slot. This is more easily done if the ratchet on the brace is used and the crank is backed up slightly every quarter or half turn.

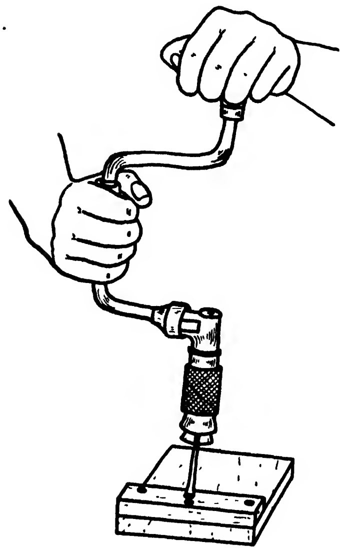


Fig. 3-105. Driving screws with the screw-driver bit. By backing the crank a little every quarter or half turn the bit is kept in the screw slot.

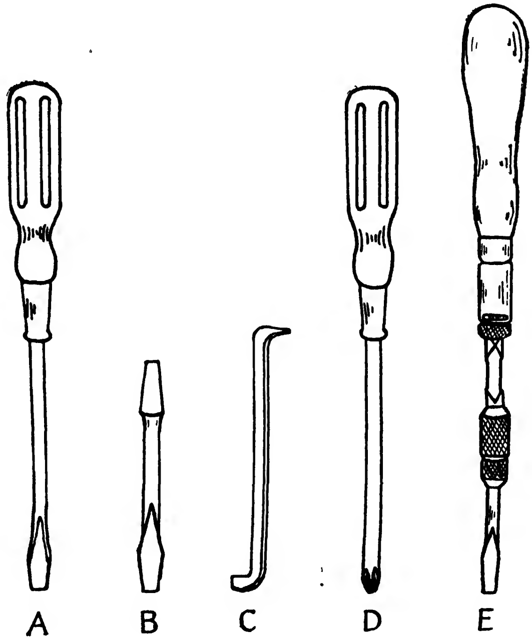


Fig. 3-106. Types of screw drivers: *A*, standard screw driver; *B*, screw-driver bit; *C*, offset screw driver; *D*, Phillips screw driver; *E*, spiral-ratchet screw driver.

Using other types of screw drivers The *offset screw driver* (Fig. 3-106*C*) is for use in close quarters where a standard screw driver cannot be used. It has a short blade on each end, one in the same plane as the handle and the other crosswise to the handle. To use such a screw driver, place one end in the screw slot and turn the screw as far as possible; then reverse the screw driver and turn the screw as far as possible with the other end. The *Phillips screw driver* (Fig. 3-106*D*) has a special cross-shaped blunt-pointed blade to fit into the recessed head

of Phillips type screws. With this type of screw and screw driver, there is little danger of the blade slipping from the screwhead. Phillips screws are widely used in the automotive industry. A *spiral-ratchet screw driver* (Fig. 3-106*E*) is one that can be used to impart a rotary motion to the screw by pushing on the handle and, when properly set, to impart an intermittent rotary motion by simply twisting the handle back and forth. When using such a screw driver by pushing on the handle, be especially careful not to allow the blade to slip from the screw slot.

Fastening with glue

Several different kinds of glue are available on the market. *Animal glue, casein glue,* and *cold liquid glue* are the kinds most generally used in the average shop. Each kind has its advantages. Animal glue is strong, casein glue is more water-resistant, and cold liquid glue is always ready for use. Animal glue, which comes in flakes or sheets, is prepared by breaking into small pieces, soaking in a definite amount of water, and then carefully heating in a gluepot. It is applied hot. Casein glue, which is made from one of the ingredients of milk, is sold as a dry powder. It is prepared for use by stirring it in water in accordance with the directions on the container. Since it is reasonably strong, water-resistant, and easily and quickly prepared, it is favored by many for general shop use. Cold liquid glue is always ready for use and is commonly used for general repairwork and odd jobs, although it may not be so strong or so water-resistant as more other kinds of glue.

Success in the use of glue depends largely upon the care used in following directions. Warming of cold liquid glue is important in cold weather, and thinning with alcohol or such other appropriate thinners as may be indicated on the container is important if the glue is too thick, owing to age and to evaporation from a container that was not tightly sealed.

Applying glue Be sure that the parts to be glued fit properly and that all clamps, material, and equipment are in readiness before applying the glue. Then apply the glue thoroughly to all parts, and brush it or otherwise work it well into the pores of the wood, but do not apply more glue than is needed. (It is a common tendency of beginners to apply too much glue.) If the joint is movable, rub one piece back and forth over the other to distribute the glue thoroughly and work it into the pores.

Clamping pieces together Once the glue is applied, clamp the pieces together and allow them to stand until the glue has hardened. If regular cabinetmaker's clamps are not available, clamps may be improvised by using the vise, or the bench top and wedges, or by twisting wire or rope.

If two or more boards are to be glued edge to edge to form a wider piece, the edges must be carefully jointed, that is, made straight and square with the working surfaces of the boards. If the boards are to be planed after gluing, they must be so placed that the grain will run the same way in all of them. If the grain should run one way in one board and the opposite way in the adjoining one, it would be impossible to plane one smooth without roughing the other.

Glued joints are generally reinforced by the use of dowels or corrugated fasteners, or both.

Doweling A doweled joint is one in which the pieces are held together by round wooden pins called *dowels.* Figure 3-107 illustrates a typical doweled joint. Dowels are also often used instead of mortise-and-tenon joints for fastening boards together in cabinetwork. Dowels may be bought, or they may be made by splitting some straight-grained wood and planing or whittling roughly to size, and then driving the pieces through a round hole in a piece of steel called a *dowel plate.* The holes in a dowel plate are tapered slightly, and the wooden pieces are

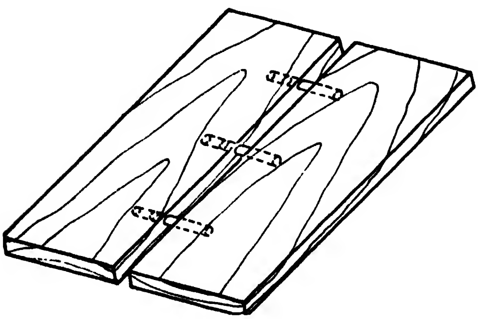


Fig. 3-107. A doweled joint ready to be glued and assembled.

driven through the small end of the hole first to prevent binding. It is a good practice to drive the piece of wood through an oversized hole in the dowel plate first and finally through a hole of the required size.

A dowel plate can be easily made by drilling holes of the desired size, usually 5/16 to 1/2 in., in a piece of steel and reaming them slightly

with a tapered reamer or with a round file if the work is done carefully. Care must be used in reaming not to enlarge the hole on one side of the plate.

Locating and boring dowel holes In using dowels, it is important that the holes be accurately located and bored so as to match and that the holes be bored perpendicular to the surface. If two boards are to be fastened edge to edge by doweling, clamp them together in a vise with the edges to be joined up and even with each other and with the working surfaces out. Locate the holes by squaring across the edges with a square and a knife or sharp pencil and by gaging about half the thickness of the pieces from the working surfaces.

Bore dowel holes the same size as the dowels. They generally need not be over 1 in. deep. Countersink the holes slightly, and point the ends of the dowels slightly. Also cut a small groove lengthwise in each dowel with a knife or saw to allow the air and excess glue to escape when it is forced into place.

8. SHAPING CURVED AND IRREGULAR SURFACES

Using the drawknife The drawknife is very useful in shaping curved or tapered surfaces, especially where considerable waste stock is to be removed. To use a drawknife, first clamp the work in a vise or other-

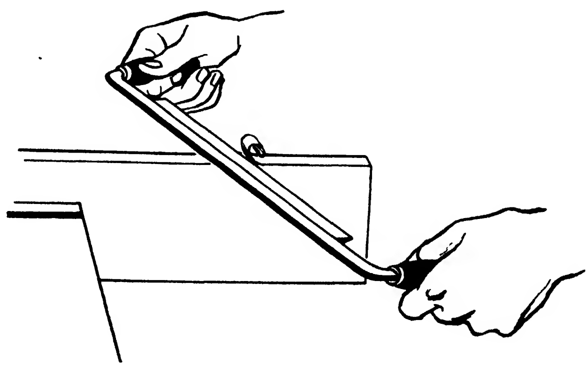


Fig. 3-108. Trimming with a drawknife. Move the blade with one handle slightly ahead of the other. This gives an oblique cutting action that enables the workman to control the tool better.

wise hold it securely. Use both hands to pull the knife, and be careful to trim or cut with the grain. Keep the bevel side of the knife up for ordinary work, and move one end of the blade slightly ahead of the other to give an oblique or sliding cut (see Fig. 3-108). This gives better control of the tool and enables the workman to cut to a line more easily.

Hewing Hewing with a hand ax or hatchet, or even with a chopping ax, is often the fastest way of removing a large amount of excess stock. A higher degree of skill is required, however, to do good work with an ax than with a drawknife.

In hewing, first deeply cut or hack the surface every inch or two with the ax, striking the surface at an angle of 45 to 60 deg, as shown in Fig. 3-109. Then remove the roughened waste by striking with the blade making a very small angle with the surface. A hand ax with a single bevel, being flat on one side, is best for hewing. As in all other cutting operations on wood, hewing should be done with the grain and not against it.

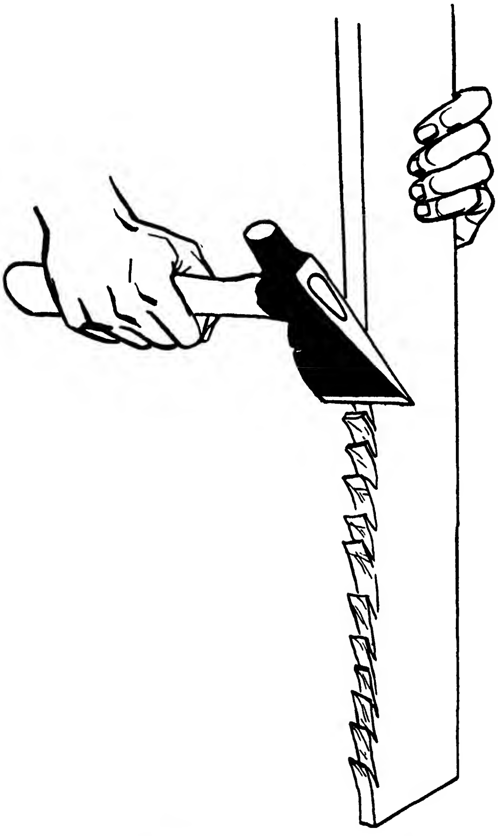


Fig. 3-109. In hewing, first hack the surface deeply and then remove the roughened waste with light, well-directed strokes.

Using the spokeshave The spokeshave is used for planing curved and irregular surfaces (see Fig. 3-110). Its action is very much like that of a plane, and the blade is sharpened and set in much the same manner. Best work can be done with the blade set to give a thin shaving. Being very short, the spokeshave can follow rather abrupt turns or curves. It is generally pushed, but may be pulled. Keeping one handle slightly ahead of the other gives an oblique or sliding cut and thus gives better control of the tool. In planing abrupt curves, use a wrist motion.

Whittling with the pocketknife The pocketknife is an invaluable tool for cutting or whittling on curved or irregular surfaces. It can frequently be used in places where it would not be possible to use other cutting tools. For best work it should be kept sharp and in good

condition. (See Chap. 7, "Sharpening and Fitting Tools," page 206, for information on sharpening pocketknives.)

The same principles apply to the use of the pocketknife as to other cutting tools, the main ones being to cut with the grain wherever possible, and not against it, and to move the blade obliquely with one end slightly ahead of the other to enable the workman to cut better to a line. In doing heavy cutting, one should always cut away from oneself. Another safety precaution is never to exert end pressure on the blade in such a manner that the blade could snap shut while in use.

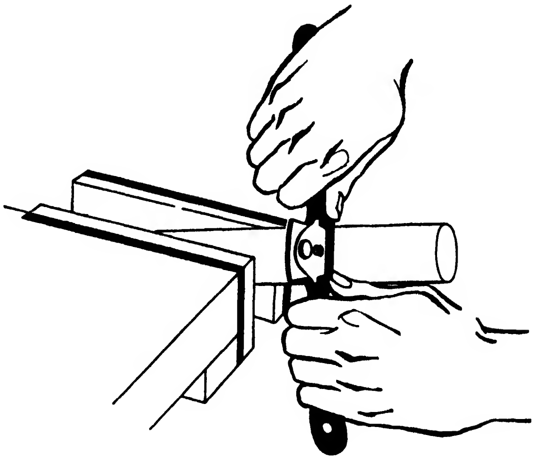


Fig. 3-110. The spokeshave acts like a very short plane and is used for planing curved surfaces.

Using rasps and files The wood rasp is valuable for removing waste in forming curved and irregular surfaces. The "half-round" rasp, with a flat surface on one side and a curved surface on the other, is usually

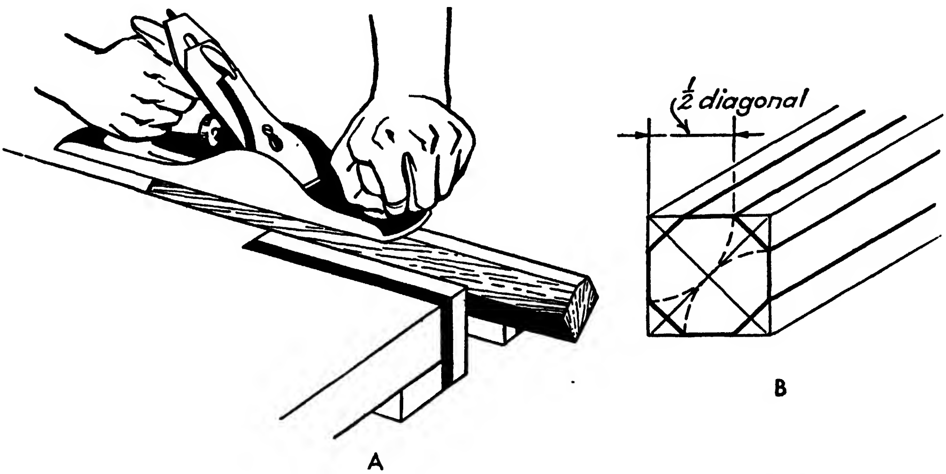


Fig. 3-111. A, by careful work a cylinder may easily be made with a plane. First make it square, then eight-sided, sixteen-sided, and finally round. B, method of marking an octagon on the end of a square stock preparatory to planing.

preferred. Rasps cut faster than files, but leave rougher surfaces. After using a rasp, the surface may be smoothed with a file or a spokeshave. A reasonably coarse file, such as a flat bastard file or a woodworker's file, is usually preferred for filing wood.

In using a file or a rasp, take full, long, steady strokes and use only a moderate speed. Lift the file or rasp slightly, or release the pressure, on the backstroke. (Fast, short, choppy strokes are the mark of an amateur or a careless workman.) Keep the file teeth clean by brushing frequently with a file card (file brush).

Sawing curves The compass saw and the coping saw are useful for sawing curves. The method of using them is explained on pages 62 and 83.

Cutting curves with the chisel is explained on page 86.

Planing a piece round To make a cylinder, such as a round handle for a tool box, first square up a piece of stock of the desired length, making it square in cross section. Then mark out an octagon on the end of the piece, marking back from each corner a distance equal to one-half the diagonal (see Fig. 3-111*B*). Next gage lines along the sides of the piece and plane off the corners, making the piece eight-sided. Then without further marking, plane off each one of the eight corners about the same amount, making the piece sixteen-sided, or practically round. Final smoothing may be done with sandpaper, rubbing the paper lengthwise of the piece.

Making a curved object In making a curved object like a hammer handle, the workman will need to rely upon his judgment much more than in making objects with flat surfaces. With curved surfaces it is difficult or impossible always to work to lines. Most articles with curved surfaces can best be made, however, by squaring up a piece of stock just large enough to make the article. Then lay out and cut curves and tapers on two edges, say top and bottom, using such tools as the drawknife, spokeshave, rasp, or file (see Fig. 3-112*A* and *B*). These curved surfaces should be made square with the sides.

Next lay out and cut curves and tapers on the other two sides; then round the corners and finish the work with such tools as the spokeshave, pocketknife, scraper, and sandpaper. If a steel scraper is not available, the sharp edge of a piece of broken glass can be used satis-

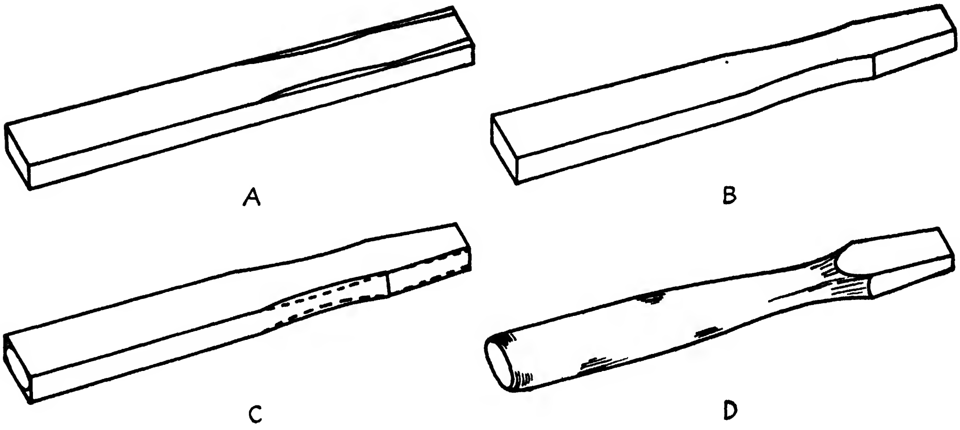


Fig. 3-112. Steps in making a hammer handle.

Fig. 3-113. Marking a board to fit against an irregular rock wall. By means of the dividers, a mark is made on the board parallel to the surface of the wall.

factorily for scraping irregular surfaces. In sandpapering an irregular surface, use a small piece of sandpaper and rub it back and forth with the grain. The paper can best be held in contact with the wood with the hand or fingers, no block being needed as in sandpapering a flat surface.

Fitting a board against an irregular surface To mark the edge of a board to be fitted against an irregular surface, such as a stone wall, hold the board firmly beside the wall and mark it with a compass or a pair of dividers, as shown in Fig. 3-113. As one leg of the compass or dividers is moved along the surface of the wall, the other leg marks off a line parallel to the surface. The legs of the compass or dividers should be set apart a distance a little greater than the width of the largest space between the board and the wall. The edge of the board can then be trimmed to the line with such tools as the saw, chisel, and drawknife.

9. CUTTING COMMON RAFTERS

Laying out a rafter is not a difficult problem if the basic principles are understood. The student should, therefore, strive to understand the principles rather than to rely upon certain rules and figures that may be memorized.

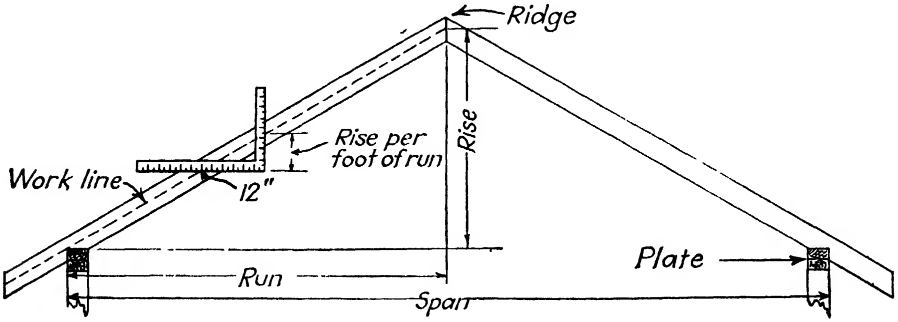


Fig. 3-114. Common gable rafters.

The main jobs in laying out a rafter are: (1) determining the angles of cut at the ends of the rafter and at the bird's mouth or seat, and (2) determining the length. This is easily done by means of the carpenter's steel square and is made possible by the fact that a rafter may be considered as the hypotenuse of a right triangle, the rise and run of the rafter being the other two sides or legs of the triangle.

The *work line* is a straight line laid off about midway between the edges of the rafter and parallel to them. It is used as a base line in measuring and marking out the rafters. (With rafter stock that is straight, it is not necessary to lay off a work line, the marking and measuring being done along one of the edges instead of on the work line.)

The *run* of a rafter is the horizontal distance measured from the outside edge of the plate to a point directly below the top end of the rafter (see Fig. 3-114). In the case of a plain gable roof with the ridge in the middle of the building, the run is half the width or *span* of the building.

The *rise* is the vertical distance from the plate to the upper end of the rafter (upper end of the work line).

The *pitch* of a rafter is a measure of its slope and is defined as the ratio of the rise of the rafter to twice its run, or as a fraction having the rise as the numerator and two times the run as the denominator. Expressed as a formula,

$$\text{pitch} = \frac{\text{rise}}{2 \times \text{run}}$$

In the case of a gable rafter, the pitch is then the ratio of the rise of the rafter to the span of the building. For a rafter having a rise of 4 ft and a run of 8 ft, the pitch is

$$\frac{4}{2 \times 8} = \frac{4}{16} = \frac{1}{4}$$

If the rise were 6 ft and the run 9 ft, the pitch would be

$$\frac{6}{2 \times 9} = \frac{6}{18} = \frac{1}{3}$$

The relationship between rise, run, and pitch may also be expressed by a modification of this formula, as follows:

$$\text{rise} = \text{pitch} \times 2 \times \text{run}$$

For example, if it is desired to find the rise of a rafter having a pitch of one-third and a run of 15 ft, substitute the values into the formula thus:

$$\text{rise} = 1/3 \times 2 \times 15 = 10 \text{ ft}$$

The *rise per foot of run* is a term used frequently in rafter work and should, therefore, be thoroughly understood. It may be determined by dividing the rise of the rafter by the feet of run; or it may be determined by use of the formula for rise given in the preceding paragraph. For example, if the pitch is one-third, substitute into the formula, using 12 in. as the run, and we have

$$\text{rise} = 1/3 \times 2 \times 12 = 8 \text{ in.}$$

If the pitch is one-fourth, then

$$\text{rise} = 1/4 \times 2 \times 12 = 6 \text{ in.}$$

Table 3-3 gives the rise per foot of run for the common pitches.

TABLE 3-3. Rise per Foot of Run and Square Settings for Common Rafter Pitches

Pitch	Rise per foot of run	Square setting
1/8	3	3 and 12
1/6	4	4 and 12
1/4	6	6 and 12
1/3	8	8 and 12
1/2	12	12 and 12

Laying out a gable rafter The laying out of a gable rafter usually involves the following steps:

1. Laying out the work line.
2. Marking the ridge cut or upper plumb cut.
3. Determining and marking the length of the main part of the rafter.
4. Marking the bird's mouth.
5. Marking off the rafter tail.
6. Shortening for the ridge board (when ridge board is used).

Laying out the work line This is best done with a chalk line. If the rafter is bowed, place the bow or crown up. The work line may be marked in the middle of the rafter, or up about 2 in. from the bottom edge in the case of a 2 by 4. The marking of the work line

may be omitted if the rafter has a good straight edge from which to measure and mark.

Marking the ridge or upper plumb cut To mark the plumb cut, place the square near one end of the stock with 12 on the body (see Fig. 3-115) and a number on the tongue corresponding to the rise

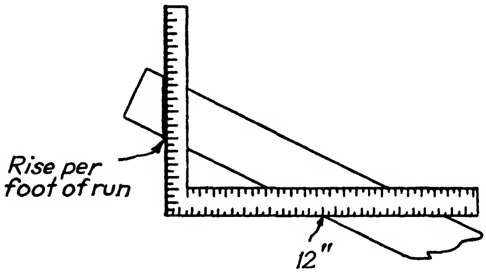


Fig. 3-115. Marking the upper plumb cut.

per foot of run, coinciding with the work line (or one edge of the rafter if no work line is used). Then mark along the tongue.

Determining and marking the length of main part of rafter

Method 1: Scaling Place the square on a piece of stock having a straight edge, with the side up which has the inches divided into twelfths. Measure the rise on one leg and the run on the other to the scale of 1 in. equals 1 ft. Make the figures on the legs of the square coincide exactly with the edge of the stock. Mark along the legs of the square with a knife or a very sharp pencil. Measure the distance between the intersections of these marks with the edge of the stock. This is the length of the rafter to the scale of 1 in. equals 1 ft. The inches and twelfths of inches on the square are simply read as feet and inches.

For example, to determine the length of a rafter having a run of 10 ft 6 in. and a rise of 5 ft 3 in., set the square with $10\frac{6}{12}$ in. on the body and $5\frac{3}{12}$ in. on the tongue coinciding with the edge of the stock (see Fig. 3-116*A*). Measuring the distance between the points of intersection of these marks with the edge of the stock, we find it to be $11\frac{10}{12}$ in. (see Fig. 3-116*B*). The rafter length is therefore 11 ft 10 in.

Method 2: Using a rafter table Probably the simplest method of determining the length of a rafter is to use a rafter table. Figure 3-117

shows such a table on a rafter or framing square. To use it, proceed as follows: Determine the rise per foot of run for the particular rafter to be marked out. Find this figure on the body of the square. Under this figure will be found another figure which is the length of common rafter per foot of run. Multiplying this figure by the total feet of run in the rafter gives the total length.

For example, to determine the length of a quarter-pitch rafter having a run of 10 ft, look under 6 on the body of the square (6 being the

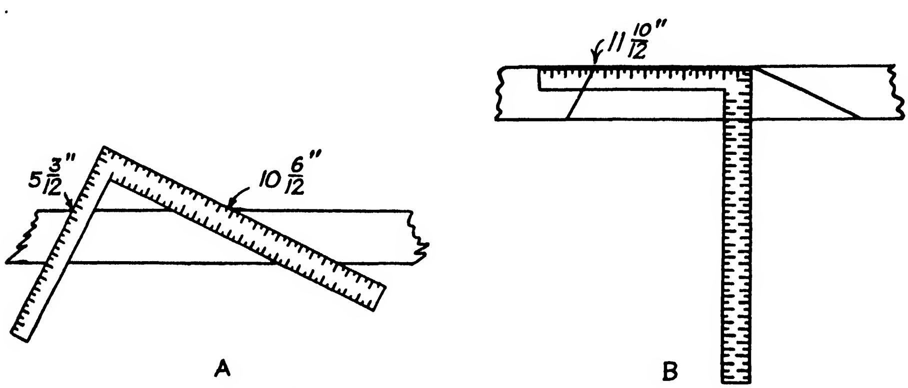


Fig. 3-116. Steps in using the scaling method to determine the length of a rafter whose run is 10 ft 6 in. and whose rise is 5 ft 3 in.

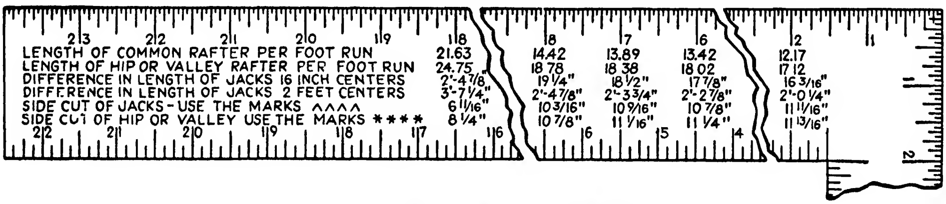


Fig. 3-117. Rafter table on a rafter square.

rise per foot of run for quarter-pitch rafters), and you will find the figure 13.42. Multiplying this by 10, we get 134.2 in. Reducing to feet, we get 11 ft 2.2 in., or for practical purposes a little less than 11 ft and 2¼ in.

On many squares the inside scale on one side of the tongue is graduated in tenths of inches to facilitate measuring off distances where decimal fractions are involved. If such a square is available, 2.2 in. may be measured off directly. Most squares also have a hundredths scale, which is 1 in. divided into 100 parts and from which decimal

fractions of an inch may be measured off with a pair of dividers. The hundredths scale is located on the back of the square near the junction of the body and the tongue.

Method 3: Stepping with square To use this method, take 12 on one leg of the square and the rise per foot of run on the other and place the square with these figures coinciding with the work line (or one edge of the rafter). Mark carefully along the body and the tongue of the square, using a very sharp pencil (see Fig. 3-118). This marks off one step on the work line (or edge). Then move the square along the stock and repeat, taking as many steps as there are feet of run in the rafter.

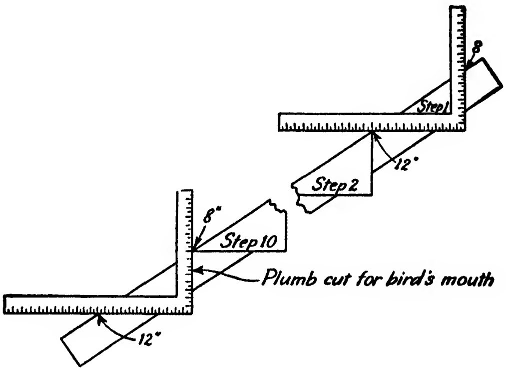


Fig. 3-118. Determining the length of a 1/3-pitch rafter whose run is 10 ft, using the stepping method.

Another variation of this method is to use a number on one leg corresponding to the total feet of run, and a number on the other corresponding to the total rise, and to take 12 steps.

Unless the work is done carefully, there is a chance for errors in marking when the stepping method is used. For this reason, many good carpenters do not use it, or if they do, they check the work by some other method.

Method 4: Using square root The length of a rafter may be determined by extracting the square root of the sum of the squares of the rise and the run. Stating this as a formula,

$$\text{length of rafter} = \sqrt{\text{rise}^2 + \text{run}^2}$$

This method gives accurate results but requires considerable involved computation with the possibility of errors in arithmetic, or the use of

tables of square roots, which are usually not available. This method therefore is seldom used by practical carpenters.

Marking the bird's mouth After the length of the main part of the rafter is determined and measured off on the work line (or one edge of the rafter), a plumb line is marked at the lower end just the same as at the ridge or upper end of the rafter. The horizontal cut of the bird's mouth is made to pass through the intersection of this lower plumb line and the work line (or, in case the work line is not used, through the mid-point of the plumb line). This horizontal cut may be

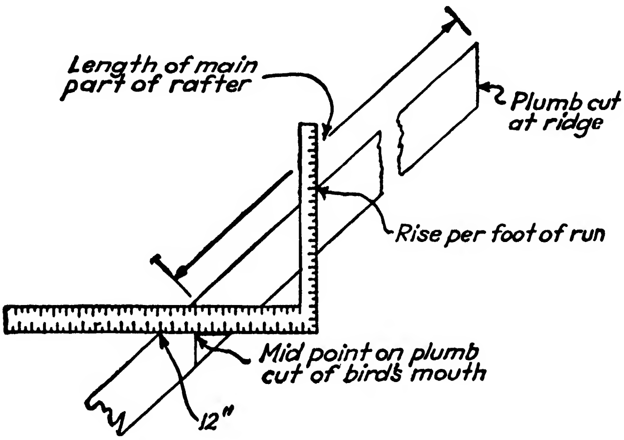


Fig. 3-119. Marking the bird's mouth.

made by placing the square with the usual figures of 12 on the body and the rise per foot of run on the tongue, coinciding with the work line (or upper edge of rafter), and moving the square up or down the stock until the edge of the body passes through the mid-point of the lower plumb line (or through the intersection of the plumb line and the work line) (see Fig. 3-119).

If the bird's-mouth notch as marked out is so deep as to weaken the rafter too much, or if it is so shallow as to give inadequate bearing on the plate, the depth should be varied somewhat to give stronger construction.

Marking off the rafter tail The length of the rafter tail, or overhanging part, and the angle of cut at the lower end of the rafter are

determined as follows: Place the square with the edge of the body along the horizontal cut of the bird's mouth, and measure out from the plumb line of the bird's mouth, the horizontal projection (see Fig. 3-120). A mark along the tongue gives the end cut.

Shortening for the ridge board If a ridge board is used, the rafter will have to be shortened by an amount equal to half the thickness of the ridge board, this amount to be measured back from the end of the rafter perpendicular to the plumb cut, and not parallel to the edges of the rafter (see Fig. 3-121).

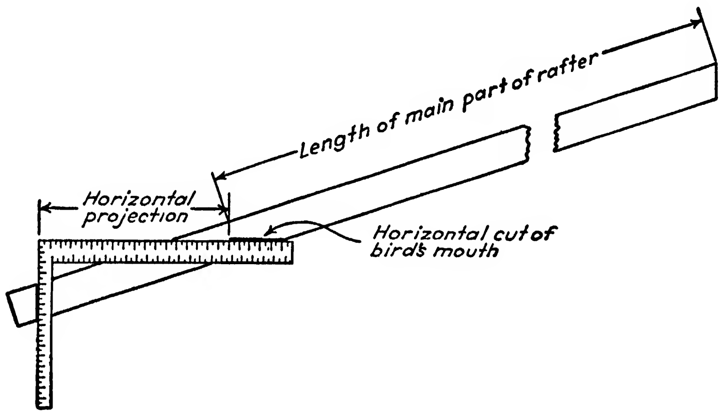
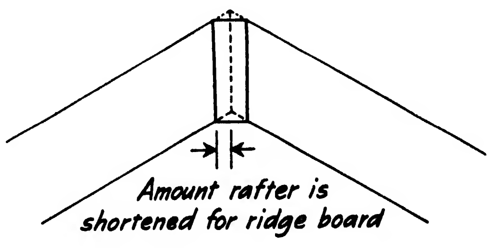


Fig. 3-120. Marking off the rafter tail.

Fig. 3-121. If a ridge board is used, shorten each rafter one-half the thickness of the ridge board. Measure back perpendicularly to the plumb cut.



10. BUILDING STAIRS AND STEPS

Building stairs and steps is often considered a job for only experienced carpenters. A knowledge of a few simple principles, however, will enable most ordinary mechanics to build porch stairs, stairs in barns, and stairs in other buildings where fine carpentry is not required. Laying out and cutting stair stringers or supports is very similar to laying out and cutting common rafters.

In building stairs it is important to plan and design the work carefully before doing any cutting. The first step is to determine the rise and run of the whole flight of stairs, and the rise and run, or tread, of the individual steps.

Determining the rise of each step A rise of about 7 in. per step is generally preferred, and it should seldom be more than 7½ in.

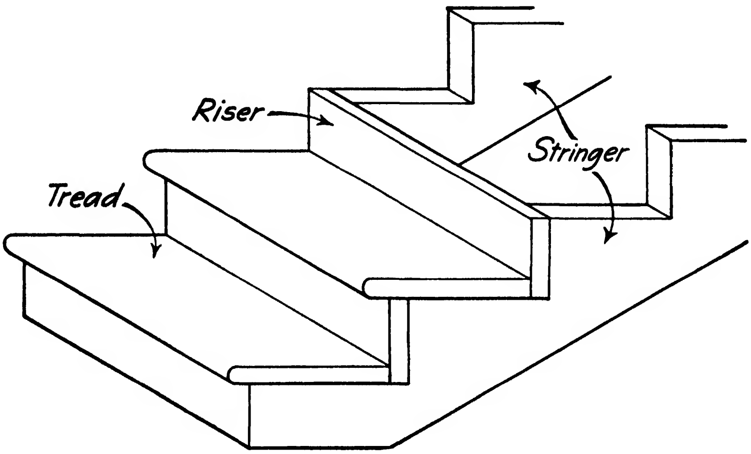


Fig. 3-122. Parts of stairs.

Measure the total rise of the flight of stairs by measuring vertically from the ground or from the lower floor level to the floor level above. Then divide this total rise into a number of equal parts so that each is as near 7 in. as possible. It is important that all steps in the flight, including both the bottom step and the top step, have the same rise.

If the total rise is not an even multiple of 7 in., then decrease or increase the rise of each step a little from 7 in. so that when multiplied by some whole number, the product is exactly equal to the total rise.

Another way of determining the rise per step is to measure off the total rise on a board and then set a pair of dividers to 7 in. and step off the marked measurement on the board. If there is a fraction of a step left over, increase or decrease the setting of the dividers and step off the measurement again, repeating, if necessary, until the total rise is divided into a number of exactly equal parts. This will give the rise of each individual step and the total number of risers on the stairs. (A riser is the vertical board between two treads on a staircase.)

Determining the run or width of tread of each step A preferred run or width of tread for a step is 10 in. It should seldom be less than 9½ in.

Multiply the desired width of tread, say 10 in., by the number of risers less one. (There is always one more riser than treads.) This gives the total run of the stairs. The total run can usually be varied within certain limits, and if the total run, as determined above by multiplying 10 in. by the number of risers less one, is satisfactory, use 10 in. as the

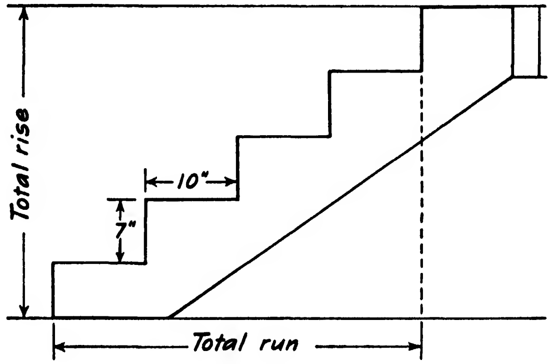


Fig. 3-123. The first step in planning stairs is to determine the total rise and the total run, and the rise and the run, or tread, of the individual steps.

tread width. If the total run cannot be an even multiple of 10 in., then use a slightly wider or narrower tread, making the sum of all treads equal the available total run.

Laying out and cutting a stair stringer With the square set on the tread and rise figures, mark the first notch near the lower end of the plank (see Fig. 3-124). Be sure the top edge of the plank is straight and square with the sides. Plane the edge if necessary.

Then turn the square around and measure down a distance equal to the height of the riser less the thickness of the tread board, and mark the bottom cut perpendicular to the riser line (see Fig. 3-125). The first riser is shortened the thickness of the tread board so that all steps in the flight will have the same rise.

Mark the required number of notches, with the square set on the tread and rise figures, and saw them out carefully. The details of the upper end of the stringer depend upon how it is fastened in place. Lay out and saw as required.

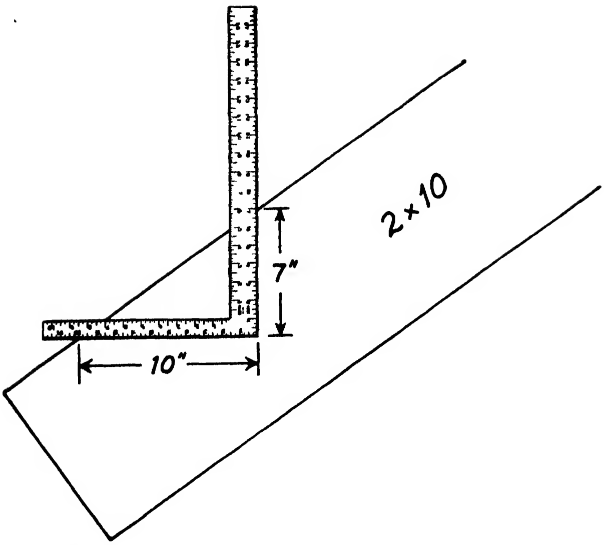


Fig. 3-124. Set the square on the tread and rise figures and mark the first notch near the end of the plank.

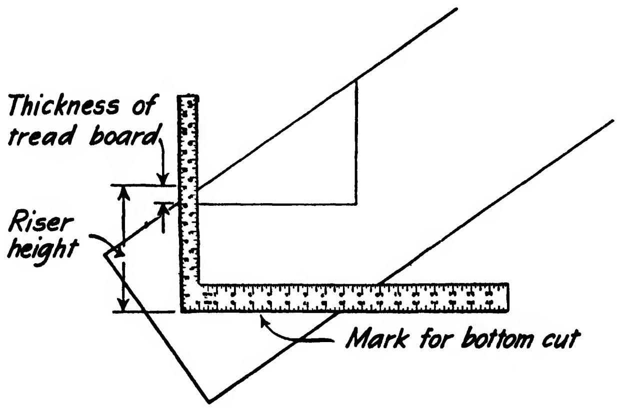


Fig. 3-125. Turn the square around and measure down a distance equal to the riser height less the thickness of a tread board, and mark the bottom cut at right angles to the riser line.

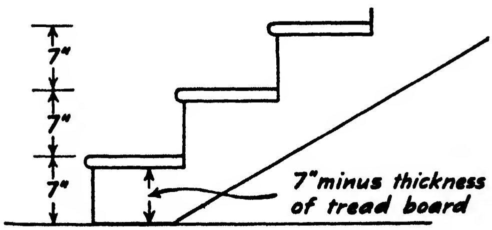


Fig. 3-126. The first riser is shortened the thickness of the tread board so that all steps will have the same rise.

11. LAYING OUT AND ERECTING A SMALL BUILDING

Before starting a building, one should have a complete working plan and bill of materials. The plan may be taken from some bulletin or a farm paper, or it may be drawn by the builder himself. The important thing is that it be well worked out and in detail so as to avoid delay and waste of materials in construction. In deciding upon a plan, it is well to study all available plans and select the one that best suits the particular needs. Often a more or less standard plan may be used, with perhaps only minor, if any, alterations.

When a plan has been chosen, it should be carefully studied and the various details of construction understood before the actual work of construction starts. All required materials and tools should be on hand, or there should be assurance that they will be available as needed.

Laying out the foundation To lay out a foundation for a building, first mark out one side or end (see line *AB*, Fig. 3-127). It is usually

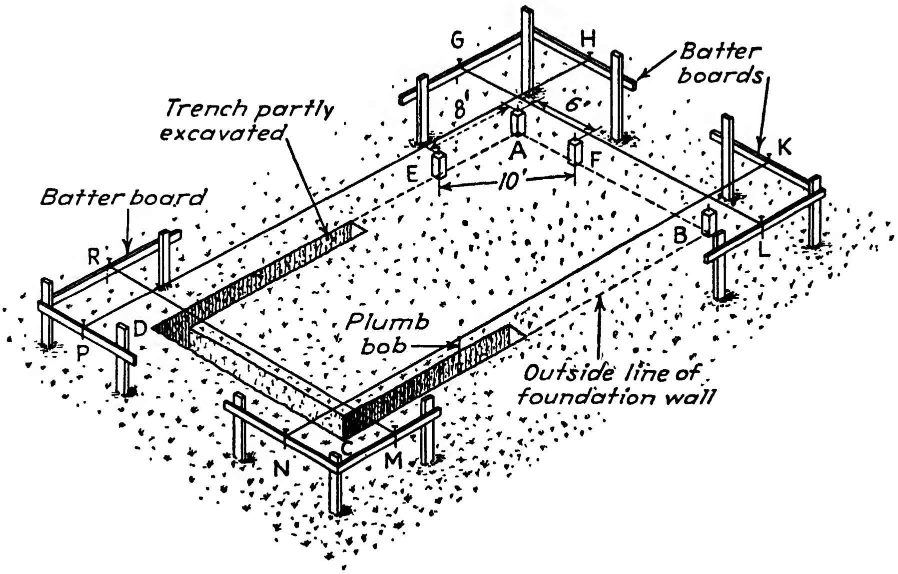


Fig. 3-127. A method of laying out square corners and of using batter boards to establish building lines. (Portland Cement Association)

desirable to make this end or side parallel or perpendicular to the side of some other building or a road or fence line. Set stakes *A* and *B* on this line, locating two corners of the building. Then drive nails in the

top of each stake to locate the corners exactly. Next drive another stake, *F*, on line *AB* 6 ft from *A*. Drive a nail in the top of stake *F* exactly 6 ft from the nail in stake *A*. Then drive stake *E* and put a nail in the top exactly 8 ft from the nail in stake *A* and exactly 10 ft from the nail in stake *F*. The corner *EAF* is then a right angle. This method of laying out a right angle is known as the 6-8-10 method. Extend line *AE* to form the second boundary line of the building, and establish the other corners in a similar manner. It is a good plan to check the accuracy of the work by measuring the diagonals *AC* and *BD*. They should be equal in length.

After the corners of the building are located, drive stakes and put up batter boards, outside the building lines, as shown in Fig. 3-127. Then stretch strings between the batter boards, so that they intersect exactly over the nails in the corner stakes. The batter boards should be set level and at the height of the top of the foundation or at some other convenient height.

Digging the trench and constructing the foundation A foundation wall should have a footing or broadened base to carry the load without appreciable settling. The size of the foundation and the size and the depth of the footing depend upon the size of the building to be supported and the type of soil. For small buildings like poultry houses on average soil, footings 12 in. wide and 8 in. deep are large enough.

If the soil is firm and the digging is done carefully, the trench may be simply widened at the bottom as shown in Fig. 3-128. If the soil is crumbly, however, or if an especially thorough job is to be done, dig the trench wider and make the footing and foundation as shown in Fig. 3-129. The foundation can be built of brick, tile, or stone if desired instead of concrete.

While the footing should extend below the frost line to avoid heaving from freezing in the case of major buildings, a depth of about 2 ft is usually considered adequate for small buildings like poultry houses, garages, and machine sheds. Always extend footings to firm, well-settled soil, however. The foundation walls should usually extend at least 12 in. above the ground line. They should be at least 6 in. thick for the smaller buildings, and up to 10 or 12 in. for large ones.

When the foundation has been built to within 6 in. of the top, embed ½-in. bolts about 10 in. long in the foundation about every 8 ft to hold the sills in place.

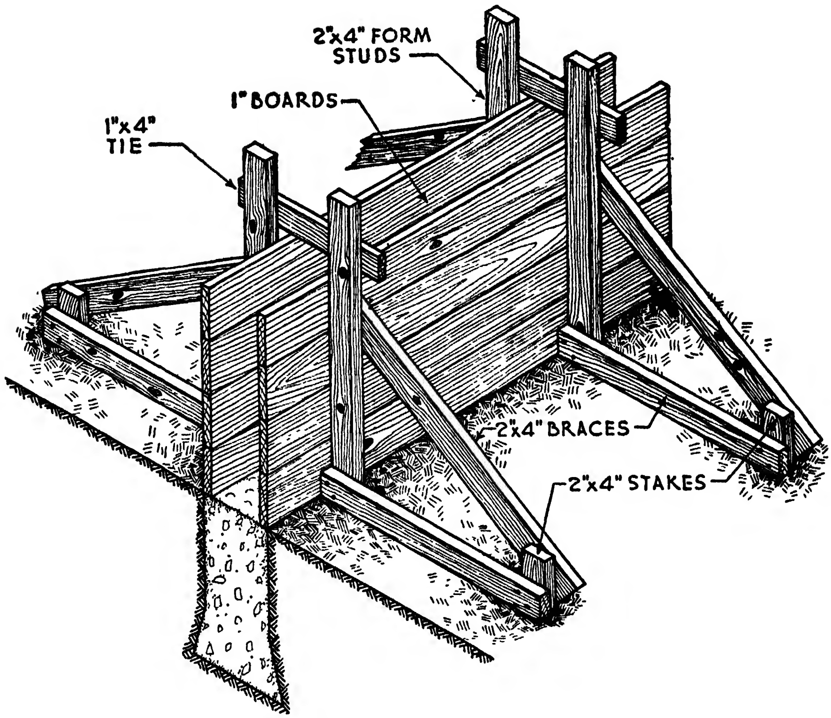


Fig. 3-128. Foundation wall forms may be made in this manner provided the soil does not crumble or cave and a wide footing is not required. (Portland Cement Association)

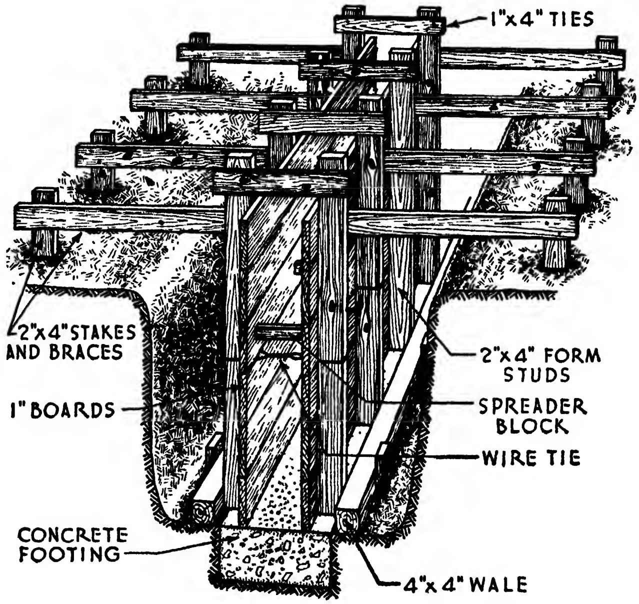


Fig. 3-129. A good method of making foundation forms when footings are required. (Portland Cement Association)

See Chap. 10, "Concrete Work," pages 307 to 325, for methods of making and handling concrete.

Building the floor The kind of floor used will depend upon the kind of building, the desires of the owner, and the amount of money to be spent on it. Concrete, wooden, or even earth floors are variously used

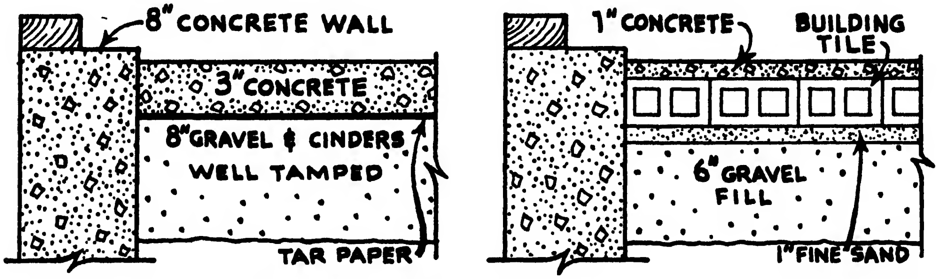


Fig. 3-130. Two styles of laying house floor construction. (*Everybodys' Poultry Magazine*)

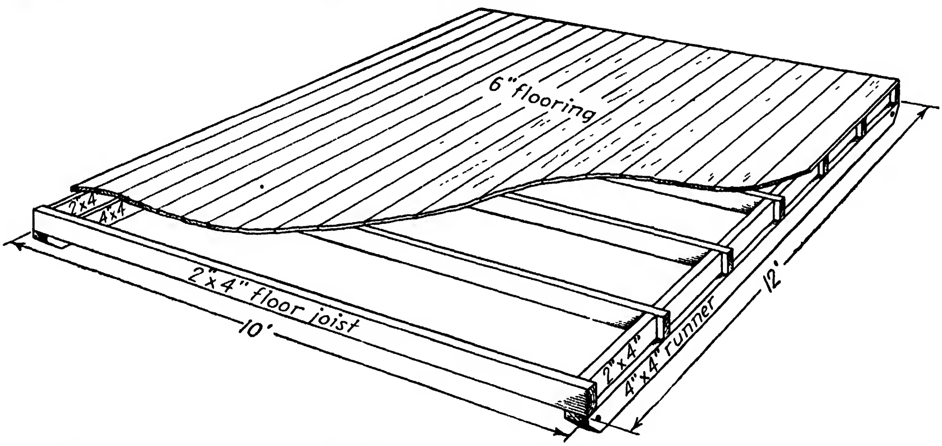
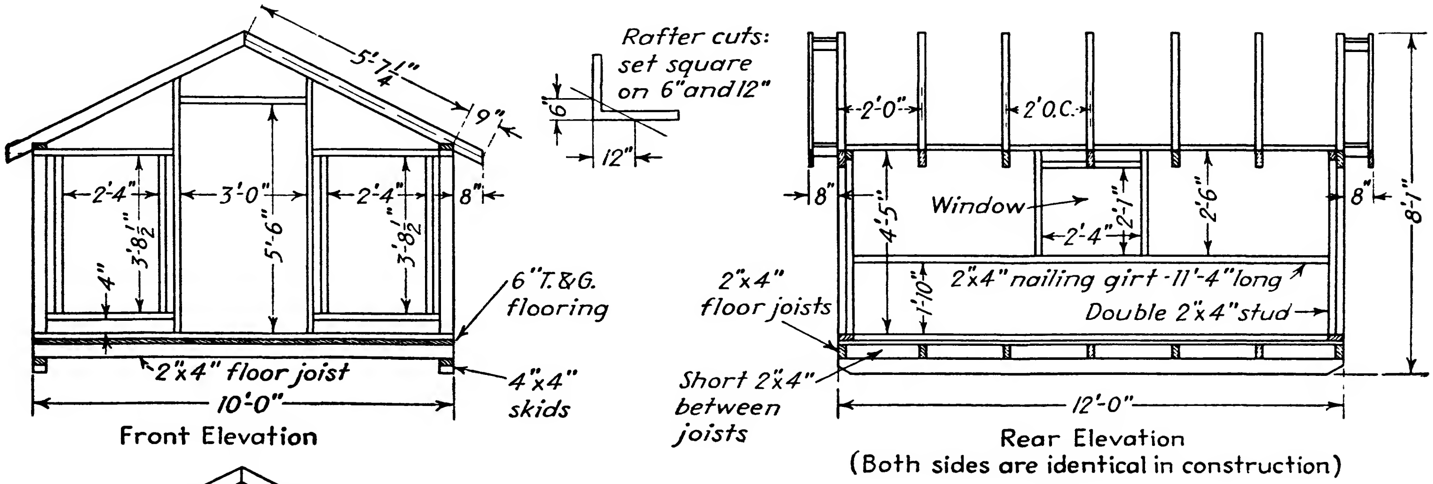


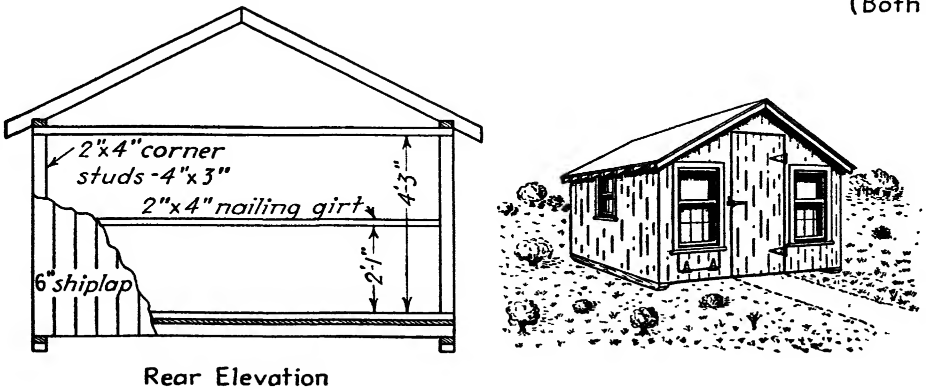
Fig. 3-131. A method of building the floor for a portable brooder or poultry house.

in farm buildings. Concrete is usually preferred for poultry houses, except for small portable ones.

For a poultry house, use a fill of 6 to 8 in. of well-tamped cinders, gravel, cr crushed stone placed inside the foundation walls, and place the floor on top of the fill. This is to avoid dampness working up through the floor by capillary action. Two styles of poultry-house floor construction are shown in Fig. 3-130.

For a small-colony brooder house or portable poultry house, build the floor as shown in Fig. 3-131. The floor joists are nailed in place crosswise on the main runners, and the flooring is nailed onto the floor joists.





Bill of Materials

14 - 2"x4"-12'

2 - 4"x4"-12'	9 - 2"x4"-10'
7 - 2"x4"-14'	2 - 1"x4"-14'

22 pcs. - 8" Shiplap - 14' lengths - sheathing
24 pcs. - 6" T&G flooring - 12' lgths. - floor
40 pcs. - 6" Shiplap - 12' lengths - siding
1500 shingles - laid 4 1/2" to weather
4 - 6 lite barn sash 8"x10" glass
2 - squares of muslin for front windows approximately 3'□

1 - pair 6" T-hinges	
7# 4d shingle nails	1 pair 4" T hinges
16# 8d box nails	2# 8d common nails
13'-6" ridge roll	1 hasp and staple for door

Fig. 3-132. Plans for a 10- by 12-ft brooder house.

Erecting the walls Fasten the sills to the foundation walls, or on top of the floor in the case of a portable poultry house, and erect the framework according to the plan being used. Nail or otherwise securely fasten all pieces. Determine the locations for the windows and doors, and cut and nail in the framework for them.

After the framework for the walls is in place, install the siding or other material to be used on the outside walls. In the case of horizontal siding, start at the bottom and work up and in the case of vertical siding, start at one corner and work around the building.

Putting on the roof Cut the rafters, and erect and nail them securely in place. Be sure to mark all of them from the same pattern and to saw carefully to the lines. See page 118 for information on laying out rafters. Next put on the roof sheathing, using solid sheathing for composition shingles or roll roofing and 1 by 4s spaced about 1¼ in. apart for wooden shingles. For a tight draftproof roof, it may be desirable to use solid sheathing even for wooden shingles. Start laying the shingles or other roofing along the bottom edge of the roof, and work toward the top. Roll roofing should be carefully sealed at the joints with roofing cement. Any special instructions of the maker of the roofing should be carefully observed.

Finishing the building After the walls are up and the roof is on, install the doors and the windows. Put on the window and door trim. To ensure good appearance, as well as a draftproof building, use care in marking, sawing, and fitting the doors and windows. Inside fixtures, such as nests, feeders, and roosts for a poultry house, are next made and installed. The location of fixtures and equipment, as well as the details of their construction, should receive considerable thought and attention.

JOBS AND PROJECTS

1. *a.* Look through shop books, manuals, and bulletins that include plans for small appliances made of wood, such as nail and tool boxes, bench hooks, sawhorses, bag holders, wood floats for concrete, book shelves, lawn chairs, workbenches, and poultry feeders. (See check list on pages 135 and 136.)
   b. List three or four that you would like to make and that you believe you could make in the shop. Select some of the simpler jobs and some that are larger and more involved.

c. Study the plans for these jobs carefully, and make sure you understand them. If the plans do not exactly suit you, sketch changes in the plans to make them suit your purposes better.

d. Make a list of the common woodworking operations, such as measuring and marking, sawing, planing, squaring up, boring, and chiseling. List them in a vertical column down the left side of a sheet of paper. Across the top of the paper, write the names of the jobs you propose to do, ruling a column for each job. Analyze each job, and check the operations involved. Would the jobs you have selected give considerable practice in all the more important operations?

2. As you make various appliances or do different jobs in the shop, be sure to practice right methods of doing the basic processes or operations. It will ensure the turning out of better jobs, and what is more important, it will enable you to acquire speed and skill in shopwork more quickly and easily.

3. Examine some woodwork jobs that have been done in the shop, possibly yours and some others. Use a grading or scoring system, such as E for excellent, S for superior, M for medium, and I for inferior, and rate the workmanship. Note, in particular, if corners and ends are square; if saw cuts are straight and smooth; if nails are well spaced, of suitable size and kind, and well driven; if screws are uniformly and neatly driven with the heads flush with the surface; if planing, chiseling, and boring have been well done; if parts have been made to dimensions called for on plans.

4. A suggested check list of things to make:

Tool box	Lawn chair or seat
Nail and tool box	Sawhorse
Wood float for concrete	Workbench
Miter box	Kitchen stool
Bench hook	Tool cabinet
Tool rack for chisels and files	Saw filing clamp
Singletree	Wash bench
Evener	Flower box
Leather-sewing clamp	Doghouse
Bag holder	Poultry water stand
Footstool	Chicken feeder

Book shelves	Nests for poultry
Ladder	Poultry crate and coop
Self-feeder for hogs	Hog crate
Hog trough	Loading chute

5. A porch stairs is to have a total rise of 27 in. The total run can be any desirable amount. What rise and run would you give the steps? How many risers? How many treads, and what width of tread?

6. The stairs to a barn loft must have a total rise of 108 in. The total run may be any desired amount up to 162 in. What rise per step and what tread width would you recommend? (*Suggestion:* Figure on the basis of 14 risers, also 15 and 16 risers.)

4 POWER WOODWORKING SAWS

1. Parts and Types of Circular Saws
2. Adjusting the Circular Saw
3. Ripping with the Circular Saw
4. Crosscutting with the Circular Saw
5. Performing Other Sawing Operations
6. The Portable Electric Saw
7. The Radial-Arm Saw
8. The Band Saw

POWER woodworking saws are great time and labor savers where much woodwork is to be done and where electric power is available. It is also easier to do smooth, accurate work with them than with handsaws. They are used principally for ripping and crosscutting and for cutting angles and bevels, but with special equipment a great variety of other work, such as cutting moldings and making special joints, can be done. Power woodworking saws are used in practically all school shops and in many farm shops.

Power saws can be quite dangerous, especially if used by inexperienced or careless workmen. It is good practice never to operate a power saw without first understanding its various adjustments and controls and knowing safe and approved methods of operation.

1. PARTS AND TYPES OF CIRCULAR SAWS

The main parts of a conventional circular saw are illustrated in Fig. 4-1.

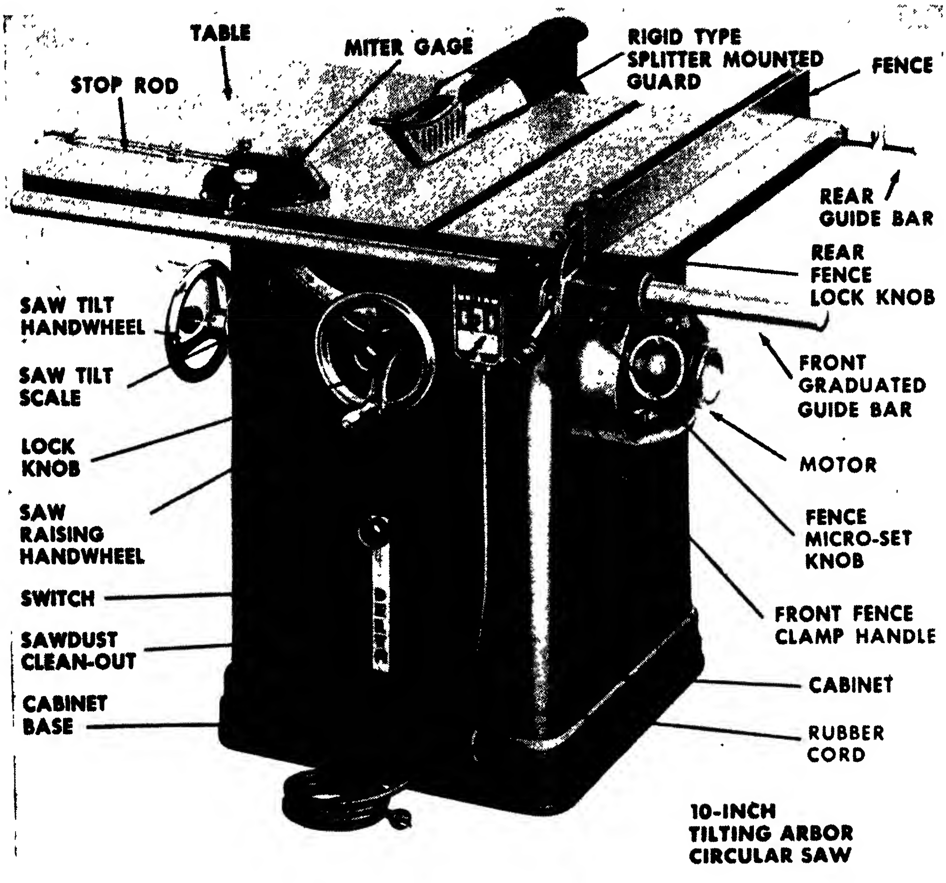


Fig. 4-1. A power woodworking saw is a great time and labor saver in the farm shop. Delta Power Tool Division, Rockwell Manufacturing Company)

The ripping fence The ripping fence is an adjustable guide used for guiding boards over the saw table in ripping. It is set the desired distance from the saw blade and then clamped in place. Most saws have scales on the front to indicate the setting of the fence, and some have fine adjustments for easily making accurate settings. Some larger saws have locks or clamps at both the front and the back of the saw table for holding the fence in place.

The miter gage The miter gage is a guide used in pushing and guiding boards across the saw table in crosscutting. It is adjustable to different angles and runs in a groove lengthwise of the table. Most saws have two grooves, one on the left and one on the right of the saw blade, so that the miter gage may be used on either side.

The saw guard and splitter The saw guard is a light metal hood fastened over the saw blade. It rises as a board is pushed under it and against the saw, and it drops down again after the board has passed the saw. It should be kept in place whenever possible. There is usually combined with the saw guard a thin piece of metal, called a *splitter,* mounted in line with the saw blade and just back of it. It prevents the saw cut from closing on the saw blade and pinching it. This would cause overheating, and might also cause the saw to kick back, that is, grab and throw the work back toward the operator. The splitter usually has antikickback fingers attached to it, which engage the work and prevent it from being thrown back toward the operator in case the saw does pinch or grab.

Types of saw blades There are three principle types of blades used on circular saws in farm shops: (1) rip, (2) crosscut, and (3) combination. Rip saw blades should be used only for ripping and crosscut saw blades only for crosscut sawing. They are recommended where considerable amounts of ripping or crosscut sawing are to be done at one time. A combination blade will rip, crosscut, or miter equally well, and is recommended where first one kind of work and then another is to be done and where the amount of any one kind done at a time is not large. Combination blades are available in taper- or hollow-ground styles as well as flat-ground. A hollow-ground blade is ground thinner below the base of the tooth toward the center of the blade and requires no set. It leaves an exceptionally smooth cut and is especially good for miter sawing. It is sometimes known as a planer blade. In addition to the above-mentioned kinds of saw blades, special blades are also available for special purposes.

Tilting-arbor and tilting-table saws Small circular saws are commonly divided into two main classes, tilting-table saws and tilting-arbor saws, according to the arrangement provided for making bevel or angle cuts. On a tilting-table saw, the table is adjusted or tilted to the desired angle for making a bevel cut, while on a tilting-arbor saw the table remains level and the saw blade, together with the arbor or shaft upon which it is mounted, is tilted to the desired angle. Tilting-arbor saws are generally preferred because of the greater ease and safety with which bevel cutting may be done. The table is always level, and it is much easier to handle the work on a level table than on one tilted at an

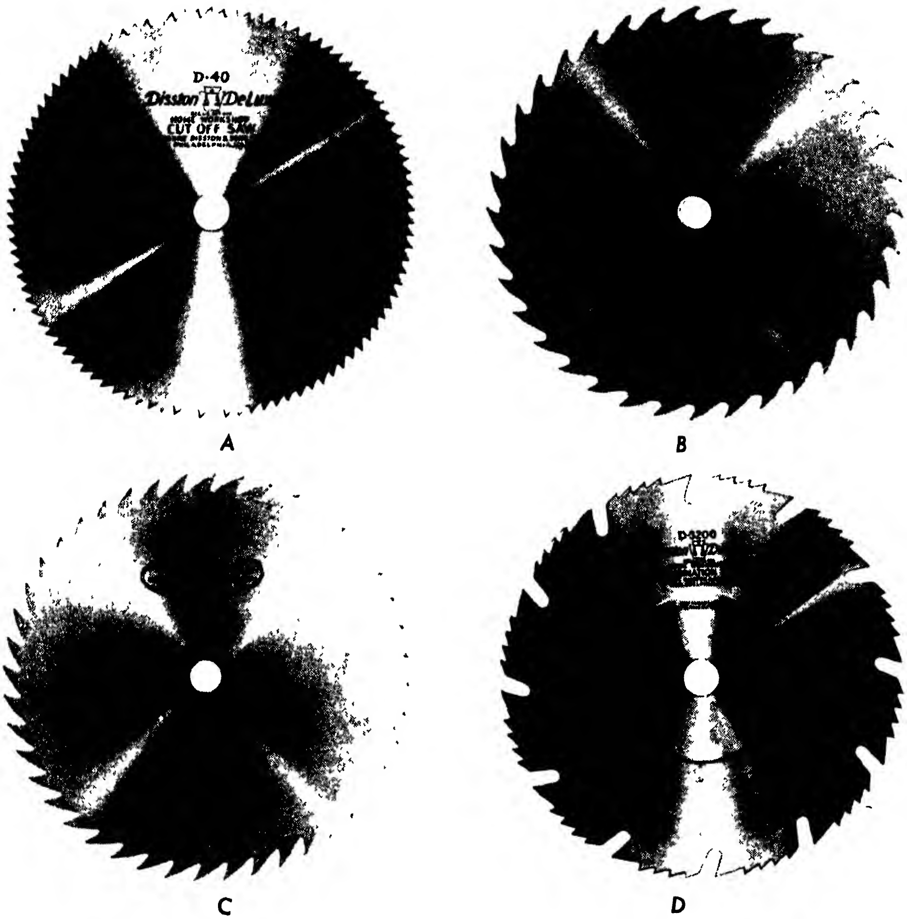


Fig. 4-2. Common types of circular saw blades: A, cutoff blade; B, rip saw blade; C, combination saw blade; D, hollow-ground combination saw blade of another type. (Henry Disston & Sons and E. C. Atkins and Company)

angle. Tilting-arbor saws are somewhat more expensive than tilting-table saws, because of the more intricate mechanism for tilting the saw blade and all its driving parts.

Saw sizes and power requirements The saw size is designated by the diameter of the blade. An 8-in. circular saw is the smallest size that should be considered for the farm shop, and for most satisfactory results it should be equipped with a motor of at least ½ horsepower (hp). It will cut stock up to 2¼ in. in thickness.

A 10-in. saw will cut stock up to 3¼ in. in thickness and should be equipped with a motor of at least ¾ hp. A 1-hp motor will generally

prove more satisfactory and should be considered if the added cost is not too objectionable and if the electric service is adequate to operate a motor of this size.

Installing a circular saw It is desirable to place the saw in good light, preferably with the light coming from the left. There should be adequate space behind and in front of the saw for ripping long boards, and also at the left for holding boards to be cut off.

If the saw is to be anchored to the floor, be sure the floor is level. A bench saw may be mounted on a sturdy bench or on a sturdy metal or wood stand. The saw table should be a little below waist level, or about 34 in. from the floor. A bag or a box mounted to the saw to catch the sawdust is desirable.

Be sure the electric wires supplying the motor are large enough to ensure good motor operation.

2. ADJUSTING THE CIRCULAR SAW

The saw blade must be parallel with the miter-gage grooves in the table, and it should be centered in the slot in the table insert. The ripping fence must also be parallel with the blade and with the miter-gage grooves. Adjustments are provided for aligning these parts, and they must be properly set if the saw is to do good work. Methods of checking and making these adjustments are outlined in the following paragraphs.

Adjusting the saw table A good method of checking the adjustment of the saw table is illustrated in Fig. 4-3. With the blade set for a

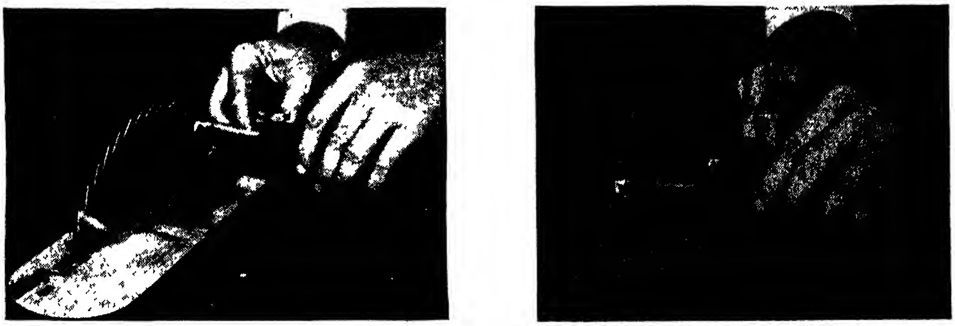


Fig. 4-3. Checking the adjustment of the saw table. The distance from the saw blade to the miter-gage groove must be the same at the front and the back of the blade.

maximum depth of cut, mount a short dowel rod or small stick in the miter gage so that it just touches a certain tooth at the front of the blade. Then turn the saw backward until this tooth is at the rear, and move the miter gage to the rear and retest on this same tooth. The dowel rod should just touch the tooth in both positions. If it does not, or if the saw is not centered in the slot in the table insert, loosen the cap screws under the table which hold it down to the frame or to the tilting trunnions, and shift the table slightly as required. Recheck the alignment, and when it is in perfect adjustment, tighten the hold-down screws securely. Some saws have adjusting screws for shifting the table slightly when the hold-down screws are loosened.

Adjusting the ripping fence A good method of checking and adjusting the ripping fence is as follows: Set the saw for a deep cut and set the fence at some convenient distance from the blade. Measure from a

Fig. 4-4. Setting the ripping fence parallel to the saw blade. The distance from the saw blade to the fence must be the same at the front and at the rear of the blade.

certain tooth at the front of the blade over to the fence. Then turn the saw backward till this tooth is at the rear, and again measure to the fence. These two measurements should be exactly the same. If they are not, loosen the adjusting screws on the fence and set it so that these measurements are the same. Then tighten the adjusting screws securely.

Adjusting the ripping-width scale To check the scale which indicates the ripping width, or the setting of the fence, move the fence over until it bears very lightly against the right side of the saw blade. The pointer on the scale should indicate zero. If it does not, loosen it, set it to zero, and tighten it.

This adjustment may be checked also by setting it for a certain width, ripping a test piece, and measuring it with a rule or square. If the piece measures slightly wider or narrower than the indicated setting, adjust the scale accordingly.

Adjusting the miter gage Probably the simplest way to check the adjustment of the miter gage is to saw a fairly wide board and check the cut with a square. If the cut is not square, adjust the lock or stop screw until the saw does make a square cut.

Many miter gages also have adjustable stops for the 45-deg positions, and these may be tested and adjusted in a manner similar to that for the 90-deg position outlined in the preceding paragraph.

Setting the tilt stops and the tilt scale The tilt stops which limit the tilting of the blade or the table may be adjusted as follows: Set the saw for a square cut, checking with a square as shown in Fig. 4-5. With the blade exactly square with the table, set the stop screw against its stop under the table to limit the tilting movement when the saw is in

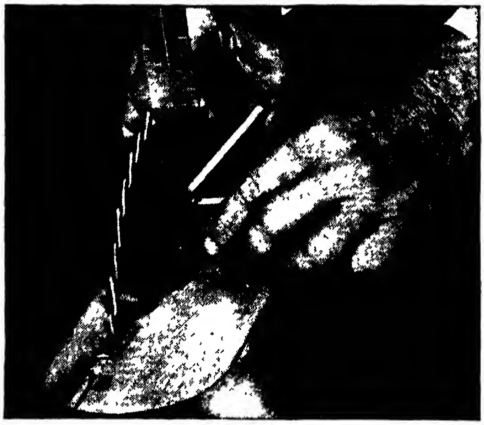


Fig. 4-5. Before setting the tilt stops, be sure the blade is perfectly square with the table.

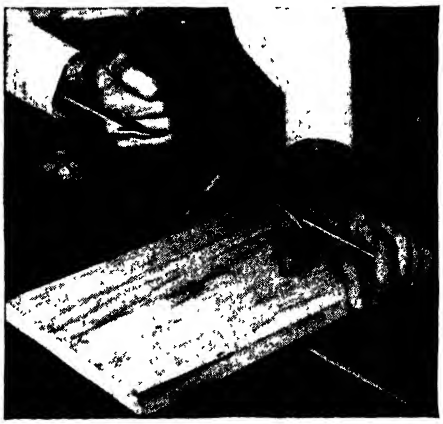


Fig. 4-6. A good way to remove a saw blade. Push a block against the saw teeth to keep the blade from turning, and turn the wrench in the direction the saw runs.

this position. Then check the pointer on the tilt scale. If it does not read exactly zero, loosen it and adjust it. Next, tilt the table or the blade to the 45-deg position, and adjust the stop in a similar manner.

Adjusting the depth-of-cut scale If the saw has a depth-of-cut scale, the pointer should be set so that it indicates the exact distance the saw projects above the table. It may be checked, of course, by measuring the depth of a cut and comparing it with the scale reading.

Removing a saw blade To remove a saw blade, remove the table insert and push a wood block against the cutting edge of the saw to keep it from turning while the arbor nut is loosened. Turn the wrench in the direction the saw runs. After a blade is installed on the arbor, draw the nut only moderately tight, as the threads are left-hand and the nut tends to tighten as the saw runs.

3. RIPPING WITH THE CIRCULAR SAW

Using a sharp blade It is important that the saw blade be kept sharp and well set. A dull blade, or one with inadequate set, is liable to bind in the saw cut and cause a kickback. It will also cut slowly and do poor work. See Chap. 7, "Sharpening and Fitting Tools," pages 249 to 250, for information on sharpening and setting saw blades.

Dirty or gritty lumber should not be sawed, nor lumber with nail holes. A nail hole might contain a broken nail or grit which would quickly dull the saw.

Setting the height of the saw blade Set the blade so that it will project through the material from ⅛ to ¼ in. If the teeth barely project through, they are liable to overload with sawdust, causing the saw to cut slowly and possibly overheat. If the blade projects through too far it will tend to throw sawdust excessively and is more likely to cause a kickback if it binds in the saw cut.

Straightening one edge of the board if necessary One edge of the board should be reasonably straight and true. Otherwise, the blade may become jammed in the saw cut and cause a kickback. Therefore, if the board does not have one straight edge, it should be straightened on a

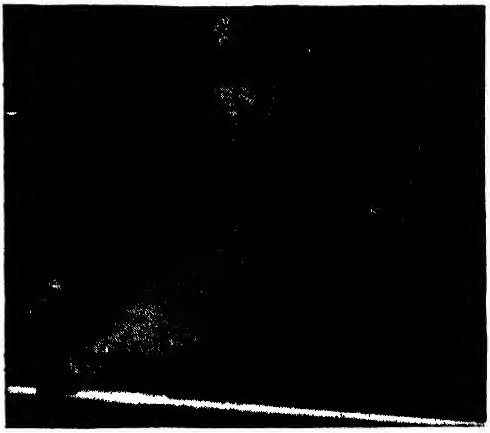


Fig. 4-7. Hold the work down against the table and over against the ripping fence with the left hand, and push it forward with the right hand, keeping the fingers close to the ripping fence.

jointer, or sawed by hand if necessary. Likewise, twisted and warped boards should not be sawed on a power saw.

Standing to one side When operating the saw, do not stand directly in line with the saw blade; stand slightly to one side. Sawdust will then not be thrown directly in your face, and there will be much less danger in case of a kickback. Be sure also that any others in the shop do not stand in line with the saw while it is in operation.

Holding and guiding the work Use the left hand to hold the work down against the table and firmly against the ripping fence. Keep the left hand on the left side of the board and as far as possible from the saw blade. Push the work forward with the right hand, fingers on top and as close to the ripping fence as possible. Feed the work into the saw at a moderate, uniform rate. Avoid fast or uneven feeding.

Ripping narrow pieces When ripping into pieces less than 3 in. in width, use a push stick to push the work across the saw table (see Fig. 4-8). It is not safe to use the hand too close to the saw blade. In case of a kickback, the hands might come in contact with the blade.

In ripping a very narrow board, use both hands and push the stock about halfway through. Then carefully withdraw the piece, turn it around and complete the cut from the other end.

Ripping long boards It is best to have a helper when ripping long boards. The helper should simply help support the boards and let the operator do the guiding and the pushing of the boards across the saw

Fig. 4-8. In ripping pieces less than 3 in. wide, it is best to use a push stick. (Delta Power Tool Division, Rockwell Manufacturing Company)

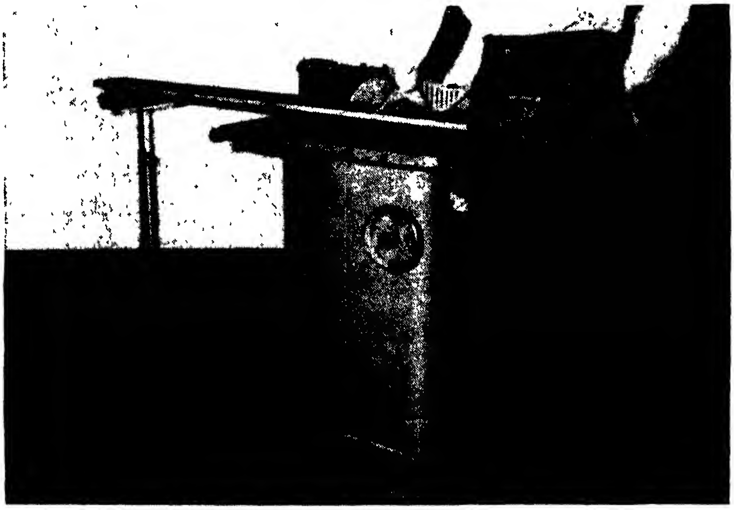


Fig. 4-9. In ripping long pieces, it is best to use a helper, or some sort of support at the height of the saw table.

table. Some sort of support set at the height of the saw table and directly back of the table (see Fig. 4-9), will enable the operator to handle medium-length pieces safely.

Ripping tapers For ripping on a taper, the work must be held in some form of jig made for this purpose. Such a jig is illustrated in Fig. 4-10. It consists essentially of two pieces hinged at one end and having an adjustment to hold them apart at the other. One member also has a shoulder to engage and advance the work over the saw table.

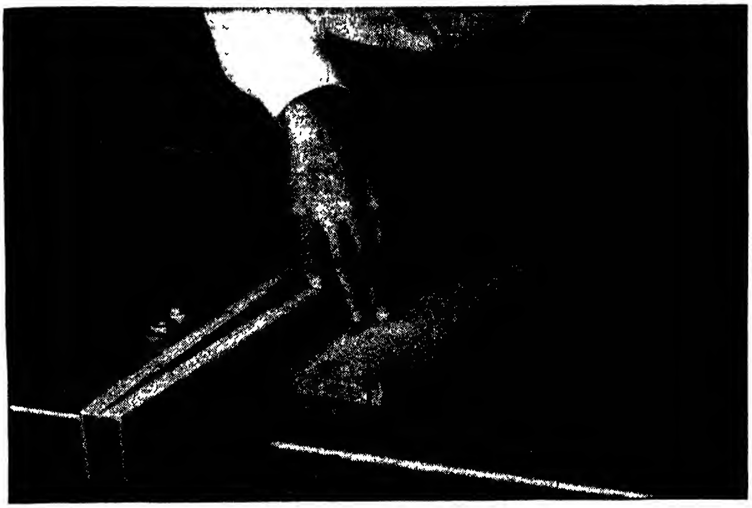


Fig. 4-10. Using a jig for ripping tapers.

A mark is scribed across the face of the jig exactly 12 in. from the hinged end, so that the jig can be quickly and easily adjusted to give the desired amount of taper per foot. For example, if it is desired to make the taper 1 in. per foot, simply adjust the spread of the two members until they are just 1 in. apart at the 1-ft line.

After the jig is set to give the desired taper, set the ripping fence to give the desired width of stock, measured at one end or the other, and advance the work into the saw.

4. CROSSCUTTING WITH THE CIRCULAR SAW

For most crosscut sawing, it is better and safer to use a wood facing on the front of the miter gage in order to give firmer support to pieces

being sawed, particularly short pieces. This facing should be at least 1 in. wider than the maximum depth of cut, and should extend at least 12 in. on either side of the blade (see Fig. 4-11). The miter gage may be used in either groove on the table top, but the left groove is preferred for most work. It is important to hold the work firmly against the miter gage as it is advanced into the saw. Use both hands, but *do not hold onto or touch the free piece being cut off*. After the cut is made, continue to hold the work firmly against the miter gage, while both the work and the gage are pulled back to the front of the saw table,

Fig. 4-11. A wood facing screwed to the front of the miter gage gives firmer support to pieces being sawed.

except in the case of long boards. With a little practice one can ease his hold on the work a little and shift it slightly away from the saw blade before returning it to the front of the table.

Cutting to exact length One of the easiest ways of cutting a board to exact length is first to mark it carefully with a pencil and then to place the board in position against the miter gage with the pencil line even with the saw kerf on the wood facing of the miter gage. A mark scribed on the table insert in line with the blade may also be used in positioning a marked board for cutting exactly at the mark (see Fig. 4-12).

Cutting several pieces to the same length When several pieces are to be cut to exactly the same length, use some kind of stop to position the work against the miter gage. But never use a stop in such a way as to bind or restrict the free end as it is cut off; and ***never use the ripping fence alone as a stop,*** as this would allow shifting and binding of the work between the blade and the ripping fence as the cut is completed.

One of the best ways of using a stop is to clamp it to the ripping fence (see Fig. 4-13*B*). A stop rod on the miter gage can often be used

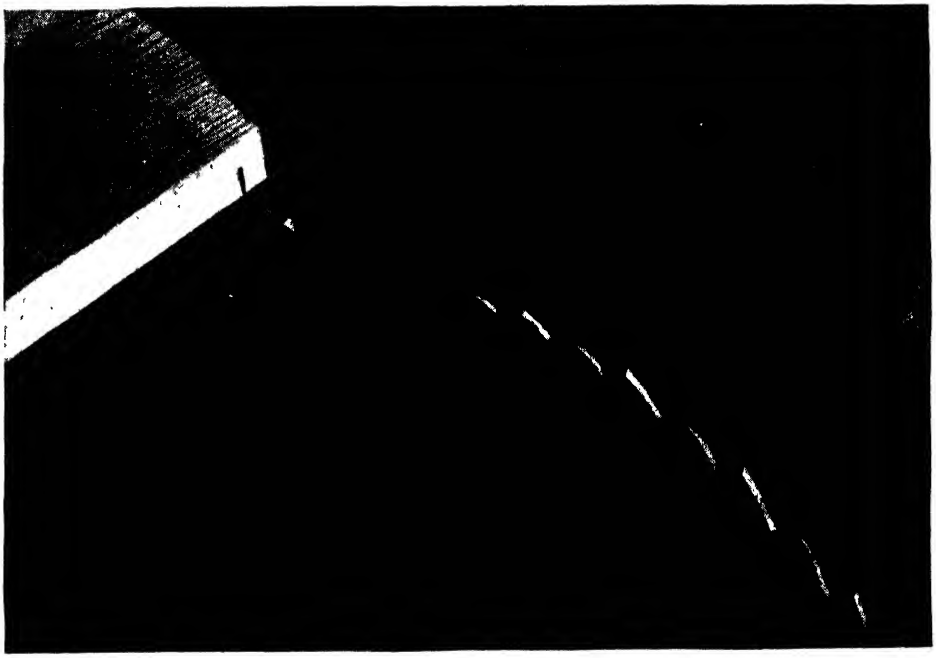


Fig. 4-12. A mark scribed on the table insert in line with the blade is useful for positioning a marked board for sawing exactly at the mark.

to advantage, but usually cannot be used with a wood facing on the miter gage (see Fig. 4-13*A*). A stop block may also be clamped to the wood facing of the miter gage (see Fig. 4-13*C*).

Sawing wide boards To saw a board that is too wide to lie on the saw table between the miter gage and the blade, reverse the miter gage in the groove, and push the board firmly against the gage as it is advanced over the table (see Fig. 4-14).

Sawing long panels A good way to saw a long, wide panel is to clamp a guide strip to the underside of the panel and allow this strip to

A

B

C

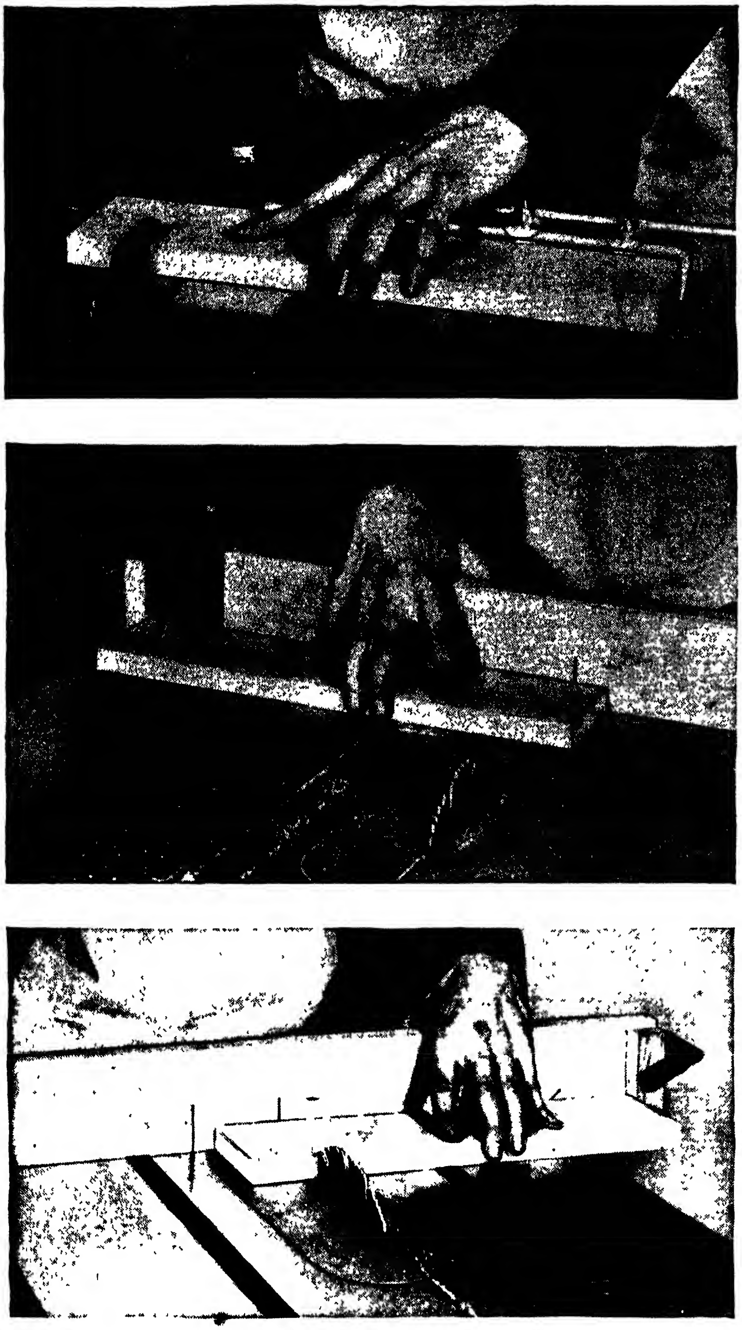


Fig. 4-13. Three good methods for sawing several pieces to the same length: *A*, using the stop rod on the miter gage; *B*, using a stop block clamped to the ripping fence; C, using a stop block clamped to the wood facing of the miter gage. (Delta Power Tool Division, Rockwell Manufacturing Company)

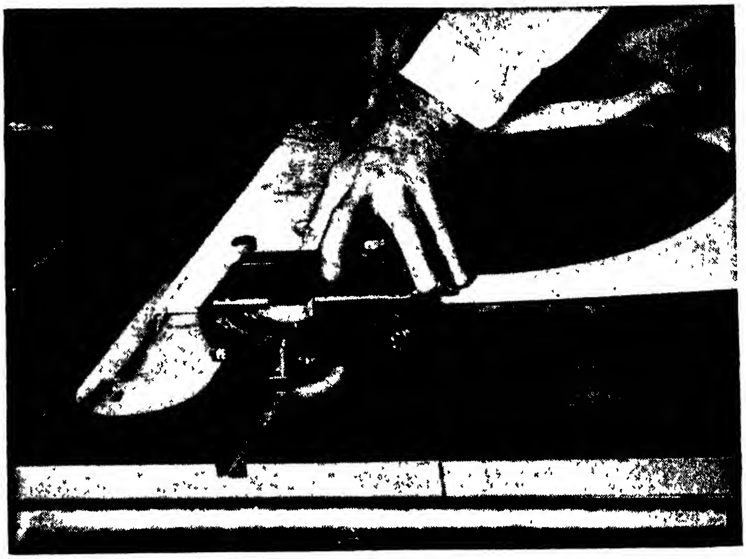


Fig. 4-14. An extra wide board may be sawed by reversing the miter gage and keeping the board firmly against the miter gage as it is advanced over the saw table.

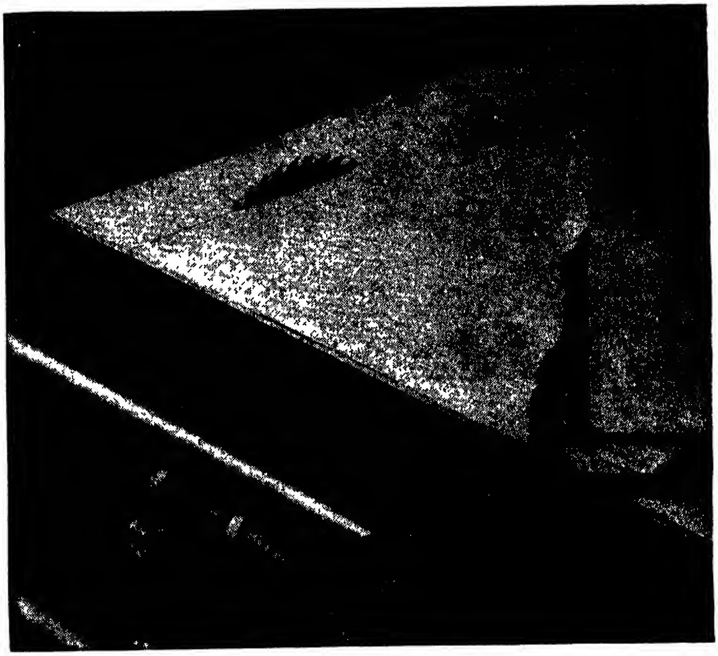


Fig. 4-15. A good way to saw a wide panel. The guide strip clamped underneath works against the edge of the saw table. (Delta Power Tool Division, Rockwell Manufacturing Company)

slide along the edge of the saw table. The strip, of course, is placed so as to make the cut come in the desired place (see Fig. 4-15). Neither the miter gage nor the ripping fence is used. One or two helpers, depending upon the size of the panel, should be used to help support the panel as it is pushed over the saw.

5. PERFORMING OTHER SAWING OPERATIONS

Sawing miters Miter sawing is done in much the same manner as straight crosscut sawing, but with the miter gage set at the desired angle instead of 90 deg. The miter gage may be used in either groove.

In sawing miters, there is much more tendency for the work to creep endwise as it is being cut. It is therefore necessary to hold the work very firmly against the miter gage and to feed the work into the saw slowly. A hollow-ground combination saw blade is preferred for sawing miters. This kind of blade reduces the tendency to creep, and it also gives a very smooth cut, which is desirable for miter joints. Another method of keeping creep at a minimum is to use screws in the wood facing on the miter gage, with the screw points projecting slightly through the facing. The points engage the work as it is held against the miter gage and help prevent creeping.

Compound miters are cut with the blade or the table tilted and with the miter gage set at an angle. It is a good plan to test the setting for a compound cut by making a trial cut in scrap material.

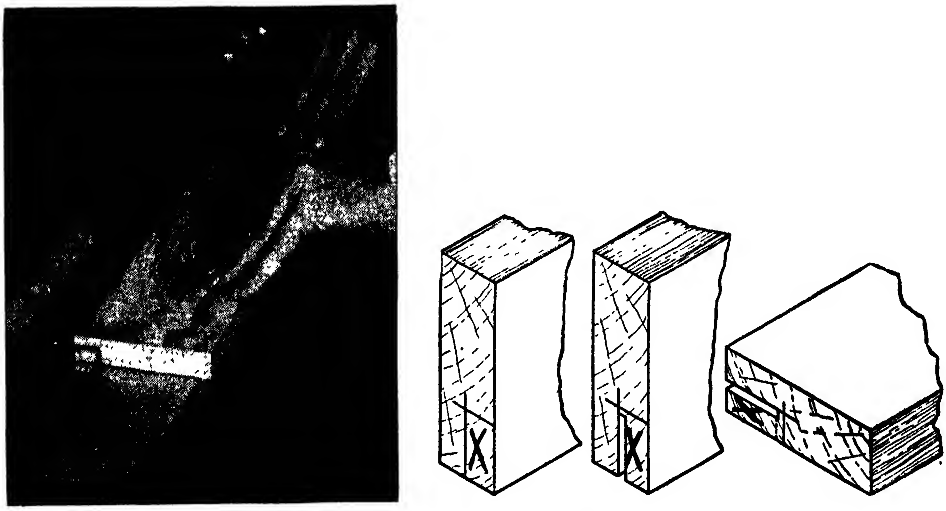
Resawing Resawing is the process of ripping stock into thinner pieces. Where the thickness of the stock does not exceed the maximum depth of cut of the saw, resawing may be done like ordinary ripping. In most cases, however, it is necessary to first saw the stock on one edge and then finish from the other edge. Stock up to 4½ in. thick may be resawed on an 8-in. saw, and stock up to 6½ in. thick on a 10-in. saw.

To resaw a thick board, remove the guard and the splitter and set the blade to project through the table a little more than half the thickness of the board. Then set the ripping fence to give the desired width and push the board on edge slowly over the saw. Keep the work firmly against the ripping fence, and advance the work only as fast as the saw will take it readily. After the first cut is made, turn the work around and make a second cut from the other end. Be sure to keep the

same side against the ripping fence. Extreme care should be used in making the second cut. It is best to have a helper pull on the work from the rear of the saw in finishing the cut.

On work where a smooth cut is not essential, resawing may be done more easily and more safely by having the saw set so that it does not quite separate the two pieces on the second cut. The job can then be easily and quickly finished with a handsaw.

Rabbeting A rabbet is a groove cut in the edge or side of a member, usually to receive another member, such as a panel. Rabbeting is



A B C

Fig. 4-16. Sawing a rabbet with a circular saw: A, mark the stock to be removed; B, make the first cut with the stock on edge, keeping the cut a little shallow; C, make the second cut with the stock on its side, and with the saw set deep enough to cut clean to the corner.

easily done on a circular saw. The saw guard and splitter will have to be removed.

To cut a rabbet, first mark it out accurately on the end of the stock which will come in contact with the saw first. Then set the ripping fence and the depth of sawing for the first cut. Make the first cut with the stock on edge and with the saw set a little shallow. On the second cut have the saw set to cut full depth, so that it will cut clean to the corner and finish the rabbet (see Fig. 4-16). In setting the ripping fence, be sure to set it so that the saw cut comes on the waste side of the marks. In making the second cut, be sure to stand to one side so

that if the saw throws the free piece at the finish of the cut, it will not strike you.

To cut a groove or a rabbet back from the edge of the stock (see Fig. 4-17), first set the depth of cut and the ripping fence and make a cut at one edge of the groove. Reset the ripping fence and make a cut at the other edge. Finally, reset the fence and make additional cuts as may be required to remove the waste between the first two cuts.

Sawing bevels Bevels are cut by tilting the table or the saw blade, depending upon the type of saw used. The saw guard usually has to be

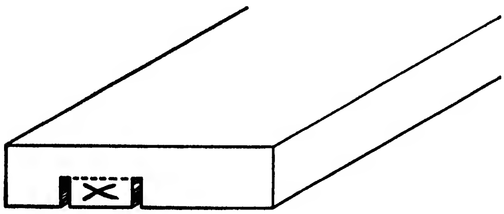


Fig. 4-17. To saw a groove or rabbet back from the edge of the board, carefully make the two outside cuts and then saw out the waste between, making as many cuts as needed.

Fig. 4-18. A dado head, consisting of two outside saw blades with spacer blades between, is useful for sawing wide grooves. (Delta Power Tool Division, Rockwell Manufacturing Company)

removed. Carefully set the ripping fence or the miter gage as may be required before starting the saw, and make sure that the miter gage, if used, will clear the blade.

Sawing dadoes A dado is a groove that runs across a member to receive the end or edge of another member. Dadoes are used mainly in cabinet work and shelving. They are easily made with a dado head on a saw. Such a head is composed of two saw blades with spacer blades or chipper blades between them to give the desired width of cut (see

Fig. 4-18). Paper washers or spacers may be used between the blades to give fine adjustment to the width of cuts.

Sawing with a dado head is done in much the same manner as sawing with a single saw blade. Hold the work firmly against the miter gage and feed it somewhat slower than with a single blade. After a setup is made, it is a good plan to make a trial cut in scrap material, and then to make any readjustments that may be needed.

Cutting tenons with a dado head A tenon may be described as a shouldered tongue cut on the end of one piece to fit into a mortise

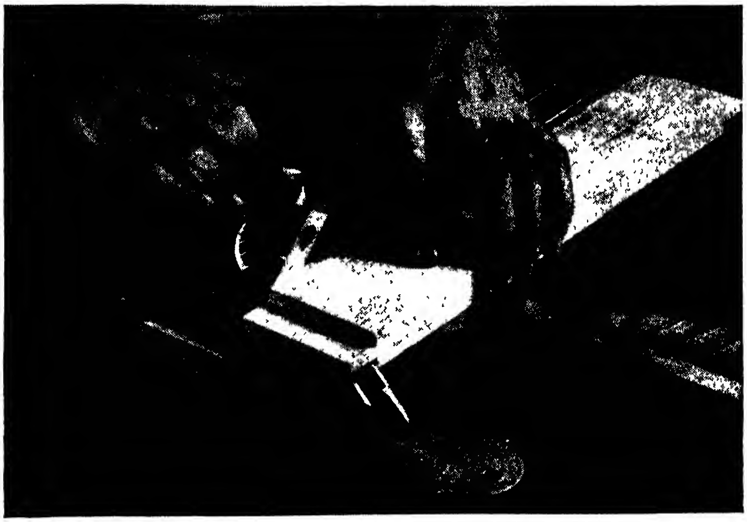


Fig. 4-19. Cutting a tenon with a dado head on a circular saw. (Delta Power Tool Division, Rockwell Manufacturing Company)

or hole in another piece. Tenons are easily cut with a dado head (see Fig. 4-19).

Cutting grooves, dadoes, and tenons with a single blade When only one or at most a few grooves, dadoes, or tenons are to be cut at one time, it may be about as easy to cut them with a single saw blade as to set up a dado head. A cut can be taken with a single blade, and the stock moved over about the width of the saw cut and another cut made, and so on until the desired total width of the cut has been made. In making grooves in this manner, it is usually best to carefully make the two outside cuts first, and then to work out the waste in between.

Cutting moldings With a special molding head, equipped with various cutting blades (see Fig. 4-20), many different decorative moldings and edgings, as well as tongue-and-groove joints, can be made easily and safely. Most cutting of moldings is straight-line work done on the edges of boards, and is accomplished in much the same manner as regular work with a blade or dado head. The ripping fence, of course, is adjusted to the desired width, and the depth of cut is adjusted to the

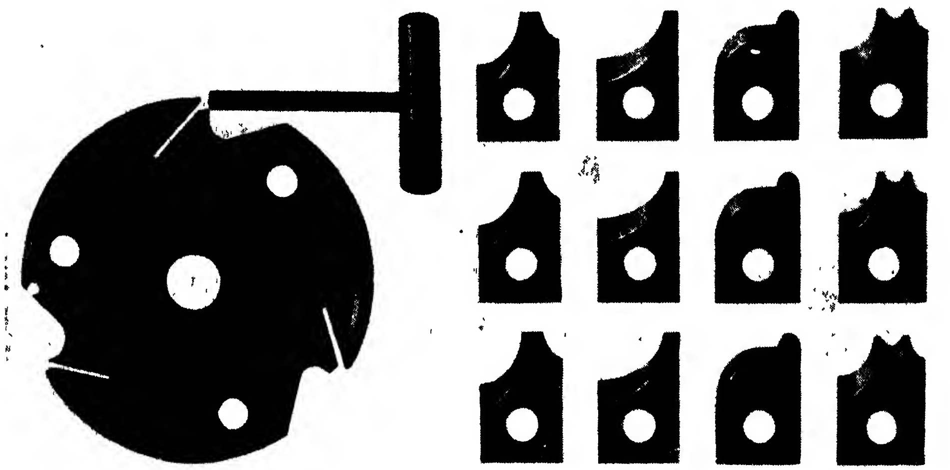


Fig. 4-20. By using a molding head, equipped with various cutting blades, many different kinds of moldings and edgings are easily made. (Delta Power Tool Division, Rockwell Manufacturing Company)

desired setting. A special ripping fence which is cut out to clear the molding head, or a special wood facing so cut out and attached to the regular ripping fence, is required.

Points on safety in using circular saws

1. Wear suitable shop clothing. Roll up shirt sleeves, and tuck tie in shirt. Remove rings and wrist watch.
2. Be sure the floor around the saw is clean and free from scraps and rubbish.
3. Saw only material that has a straight edge. Do not saw crooked or warped lumber.
4. Study the saw and its adjustments and make sure you understand them before starting work.

5. Adjust the saw so that the teeth will extend ⅛ to ¼ in. above the work.
6. Use a helper to help support long pieces on the saw.
7. Use the saw guard and splitter on all work where possible.
8. Be sure that the saw table is free of material and tools and that all adjustments are tightened before turning on the power.
9. Stand slightly to one side when operating the saw, and be sure others are out of the way.
10. Hold the material against the ripping fence when ripping, and against the miter gage when crosscutting. Never saw freehand.
11. For most crosscutting, use a wood facing on the miter gage.
12. Never use the ripping fence as a gage in crosscutting short pieces. Use a stop on the miter gage or stop blocks clamped to the ripping fence or the table top.
13. Do not place the hands over or in front of the blade. Never reach over the blade.
14. Use a push stick when ripping narrow pieces.
15. Turn off the power to remove short pieces which touch or are near the blade.
16. Stop the saw while making adjustments.
17. Do not use a dull blade or one with inadequate set. Such a blade is likely to cause a kickback.

6. THE PORTABLE ELECTRIC SAW

The portable electric saw, sometimes also called the electric handsaw, (see Fig. 4-21) cuts many times as fast as a handsaw, and is widely used by carpenters in repairing and constructing buildings. While it does have considerable use around a shop, especially when used with accessories for converting it into a table saw or a radial saw, its principal value is in repair and construction work out on a job rather than in the shop. It can be used for ripping, for crosscut sawing, for sawing of miters and bevels, and, with suitable attachments, for a variety of other sawing work.

The portable electric saw is essentially a small electric motor with a suitable handle and controls and with a small circular saw blade mounted on an extension of the motor shaft. The blade has a guard, the lower part of which telescopes up into the upper part as the saw advances into the work. The saw is mounted on a base plate, commonly

called a foot, so that it will stay in proper position as it is guided over the work.

Selecting a portable electric saw The size of a portable electric saw is designated by the diameter of the saw blade. Saws from 6 to 8 in. in size are generally preferred for farm shopwork. These saws are available in light- and heavy-duty models. A 6 in. saw has a maximum

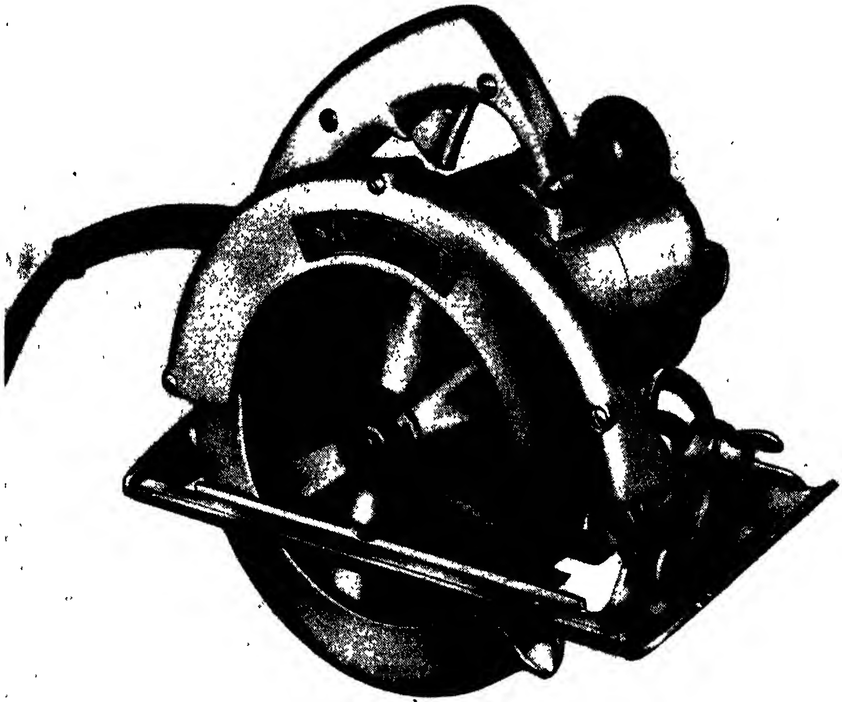


Fig. 4-21. The portable electric saw is a valuable piece of shop equipment for the farm. (Skill Corporation)

depth cut of about 2 in., and an 8-in. saw about 2⅞ in. Various kinds of blades are available for portable electric saws the same as for table saws. A combination blade is generally preferred. By means of suitable abrasive cutoff wheels, various materials such as concrete, tile, and metal may also be cut.

Selecting attachments and accessories Attachments and accessories are available for many electric saws to convert them into table saws or into saws which can be used much like radial saws. A portable electric saw may be converted into a table or bench saw by mounting it upside

down under a table with the blade projecting through the top. With a suitable ripping fence and miter gage, it can be used in the same manner as a table or bench saw.

With appropriate attachments a portable electric saw can also be mounted in a track or guide in which it can be moved back and forth with precision. The guide is mounted on a table and can be adjusted for cutting boards off square or at an angle, and also for beveling. The saw may also be turned and locked in a stationary position and used for ripping in the same manner as a radial saw. An ingenious mechanic can often design and make such attachments and accessories himself.

Adjusting the portable electric saw The depth of cut is adjusted by tilting the saw up or down about a hinged pivot at the front of the base plate. The saw can also be tilted sideways and locked at the desired angle for bevel or angle cutting. The base plate is also equipped with a simple adjustable gage for guiding the saw in making cuts at a certain distance from the edge or end of the work.

Operating the portable electric saw Be sure to understand the various adjustments and controls on the saw before attempting to operate it. It is also a good plan to try the saw in waste material, in order to get the feel of it, before using it on good material. Move the saw forward into the work slowly and evenly. Do not use excessive pressure or force the saw. If it begins to slow down, ease it back out of the cut before turning off the switch. Turning off the switch while the motor is overloaded would tend to burn the switch contacts.

To cut off the ends of several boards in a straight line after they have been nailed in place, the saw may be guided by a guide strip temporarily tacked or clamped in place. Where the saw may be placed on top of the work, and where the cut does not need to be exact, the saw may be guided freehand along a mark.

Always use a blade that is sharp and in good condition. A dull blade not only cuts slower, but is harder to control and is more likely to cause an accident. It will also tend to overheat. It is a good plan to keep one or two extra blades in good condition and ready for use in case one is dulled on the job.

Keeping the saw in good condition Only a minimum of attention is needed to keep a portable electric saw in good condition. The blades

are sharpened and set like other circular blades. The main precaution in sharpening is to maintain the original shape and angles of the teeth. See Chapter 7, "Sharpening and Fitting Tools," pages 249 to 250, for specific suggestions on saw sharpening.

In time the saw motor will need to have the brushes and commutator cleaned. The motor bearings may or may not need lubrication, depending upon the type of bearings used. See the manufacturer's instructions. Keeping the commutator and brushes free from dirt and grease will help materially in reducing shock hazards. Obviously, the electric cord will need replacing in case of cuts or breaks.

The brushes, brush holders, and commutator may be cleaned with a soft cloth moistened with gasoline, or preferably with a noncombustible cleaning fluid such as carbon tetrachloride. After considerable wear, the carbon brushes will need to be replaced. If the commutator is rough, it may be smoothed with fine sandpaper. Do not use emery cloth, as particles of emery, which is a conductor of electricity, would become embedded between the commutator bars and cause arcing or burning of the bars. If the commutator becomes badly grooved or roughened, take the whole saw to a specialized repair shop or send it to the manufacturer for reconditioning.

Practicing safety with the portable electric saw The portable electric saw is probably more dangerous than a table saw or a band saw, because of its portability and with the ease with which various parts of the body may come in contact with the blade. It is therefore important that the operator be especially careful in handling and using the saw.

There is also a certain hazard in the electric wiring to the saw. To minimize shock hazard, the portable saw is equipped with a three-wire cord, one of the wires being a ground wire. This wire should be connected to a ground, such as a water pipe or a rod driven deep into the ground, especially when the saw is used on damp footing.

Points on safety in using the portable electric saw

1. Do not use a blade that is dull or out of condition.
2. Keep the hands, legs, and other parts of the body away from the blade while it is in operation.
3. Do not use the saw in awkward positions where there might be danger of slipping or falling.

4. Do not reach over or around a saw that is running.
5. Remember that there is only little, if any, danger of shock when the ground wire is connected to a good ground. It is best always to ground the saw when working in damp places.
6. Be sure that the telescoping "lower jaw" guard is in good condition and that it works freely.
7. Push the saw slowly and steadily into the work.

7. THE RADIAL-ARM SAW

A typical radial-arm saw, also known simply as a radial saw, is illustrated in Fig. 4-22. It is used for crosscut sawing, ripping, mitering,

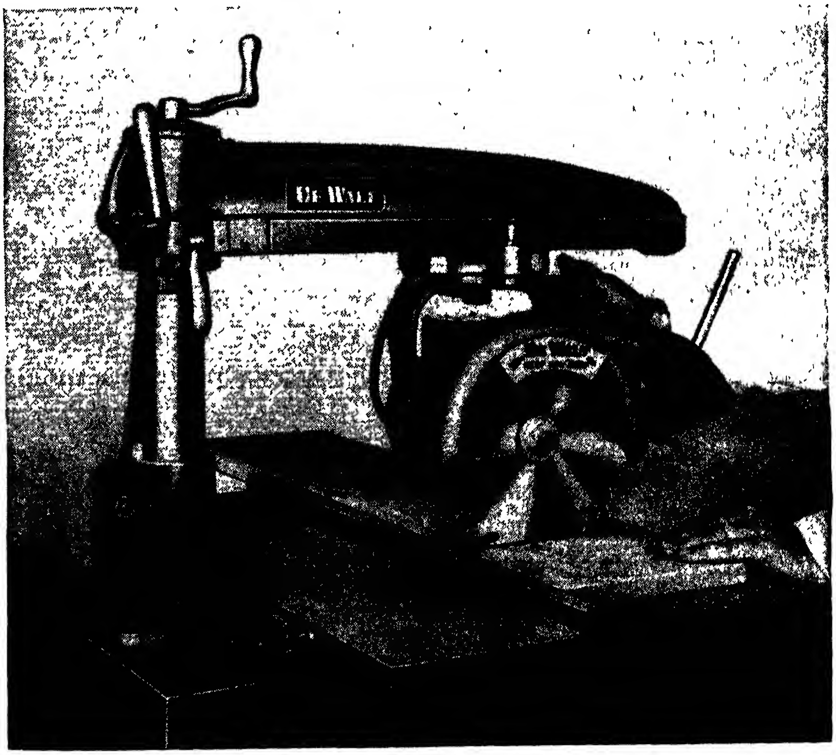


Fig. 4-22. The radial-arm saw is used for crosscutting, ripping, mitering, beveling, and other kinds of sawing. (Dewalt, Inc.)

beveling, and, with suitable attachments, for many other kinds of sawing, dadoing, and grooving. It is used principally by builders and contractors, and in lumberyards and factories. It is a precision tool and is usually built for heavy-duty service, and therefore usually costs more

than other kinds of saws commonly used in farm shops. It is used to a limited extent in school shops and occasionally in farm shops.

Auxiliary long tables are generally mounted at the ends of the regular table of a radial saw, so that long stock may be more easily handled and worked. In sawing across a board, the work is simply put in position on the table and held against the fence while the saw is drawn across it. The saw moves back and forth in a track which is mounted to the underside of the overhanging arm. This arm is adjustable up and down to give the desired depth of cut, and the track (or arm, depending upon the design of the particular saw) is swung to various angles and locked for making angle cuts. The saw motor is mounted in a fork or cradle so that the blade may be tilted at an angle with the vertical for making bevel cuts. Also, the saw may be swung through 90 deg and locked parallel with the edge of the table for ripping. The saw is moved in or out on the arm to give the desired ripping width.

A 10-in. saw operated with a 1-hp motor is usually the smallest size recommended for a farm shop. As with other saws, various kinds of blades are available. Combination blades are generally preferred.

Adjusting the radial-arm saw Before using a saw, check it to see that the various parts are in proper alignment, and that the various scales are set to indicate properly the angles and widths of cuts. The manufacturer's instructions for making these adjustments should be followed.

For ripping, set the blade at a very slight angle with the fence, the front edge of the blade being a little nearer the fence than the back edge. This gives the saw what is known as *lead.* Its purpose is to keep the blade well centered in the cut and to prevent the teeth on the back of the saw from scoring or tearing the edge of the piece being ripped. Set the saw with no more lead than is really necessary.

Various types of saw guards are used. For some kinds of work, the guard must be removed. Obviously, it should be kept in place and properly adjusted whenever possible.

Operating the radial-arm saw To cut a board off square, set the track square with the fence and place the board in position on the table and against the fence. Then start the motor and pull the saw slowly and steadily forward across the board. When the cut is finished, push the saw back into its original position before removing the board.

In crosscutting, always pull the saw from rear to front—never push it from front to rear.

To saw a piece at an angle instead of square, simply swing the track to the desired angle, lock it in place, and proceed in the same manner as for square cutting. Cutting of bevels is accomplished in the same manner as crosscut sawing, except that the blade is first tilted to the desired angle and locked in position before the saw is moved across the work. Compound miter cutting is done by having the blade tilted and the track also set at an angle.

For ripping set the arm in the square position and then set the saw blade square with the arm and parallel to the fence. Move it in or out on the arm to give the desired ripping width. With the saw locked in position, feed the board under the saw, keeping one edge against the fence to guide it straight. Be sure the saw has a suitable amount of lead as indicated in the section on adjusting the radial-arm saw. Stand to one side and feed the work to the saw at a steady speed. Bevel ripping is easily done by simply tilting the saw to the desired angle and then using it in the same manner as for square ripping.

The swing saw A typical swing saw is illustrated in Fig. 4-23. It is used principally for crosscut sawing but can be used for other kinds of sawing, such as ripping, mitering, and dadoing. It is used in much

Fig. 4-23. The swing saw is used principally for crosscut sawing, but can be used for other kinds of sawing such as ripping, mitering, and dadoing. (Sears, Roebuck and Company)

the same manner as a radial-arm saw. Instead of moving straight in and out on a track or arm like a radial saw, however, the swing saw swings on a hinged pivot located near the top of the saw mounting.

When a board is to be sawed off, it is held in place on the saw table, and the saw is simply pulled out to make the cut, and then allowed to swing back into "home" position.

8. THE BAND SAW

The band saw is used for ripping, crosscut sawing, and other general sawing, such as sawing of bevels and tapers, but is especially

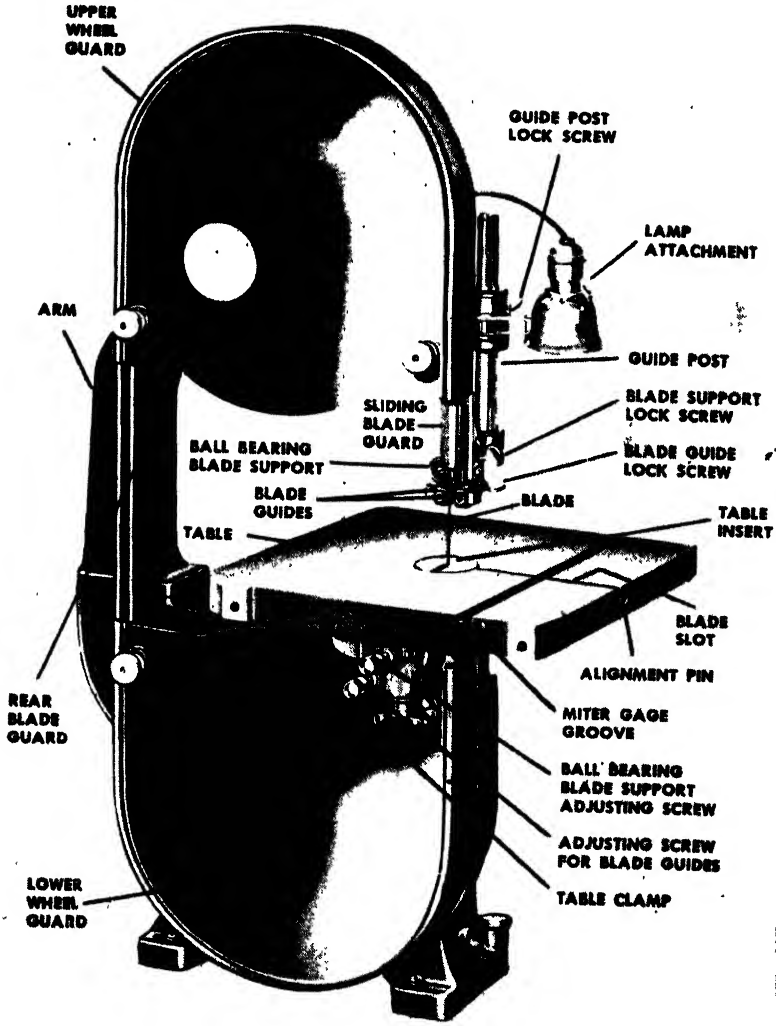


Fig. 4-24. The band saw is especially good for sawing curved and irregular pieces. (Delta Power Tool Division, Rockwell Manufacturing Company)

good for sawing curved and irregular pieces. The work may be guided against the saw freehand or with the use of a miter gage or ripping fence. The band saw is quite a versatile tool, in that many different kinds of work can be done on it. It cannot be used, however, for as heavy sawing, or as fast sawing, or as accurate sawing as the circular saw. It therefore has a much more limited use in the school shop and the farm shop.

A typical band saw is illustrated in Fig. 4-24. The cutting blade might be described as a thin, narrow, endless steel belt with saw teeth cut on the edge. It runs over two wheels or pulleys, one located above the other, the lower one being driven by a motor. The wheels and the blade, all except a short section which is exposed to the work, are covered by guards. The blade runs in two guides, one just below the table and the other above. The top guide is adjustable up and down to accommodate work of different thicknesses.

The size of a conventional band saw is designated by the size of the wheels over which the blade runs, or by the distance from the blade to the frame, which is a little less than the diameter of the wheels. A 14-in. saw is usually recommended for the farm shop. Motors of 1/3 or 1/2 hp are commonly used on saws of this size.

Operating the band saw The band saw is not difficult to operate, but like other power woodworking machines, it can be dangerous if operated carelessly or improperly. As with most machines also, an understanding of its adjustments and its principles of operation forms a sound basis for its safe and satisfactory use. The following is an outline of some of the more important points to be observed in operating a band saw.

Points on operating a band saw

1. Use only blades that are sharp and in good condition.
2. Be sure the blade guides are adjusted to almost touch the blade at the back edge and at the sides when it is running free and not cutting.
3. Stand slightly to one side of the line of sawing, and feed the work only as fast as the saw will take it readily.
4. Always keep the hands away from the blade while it is in operation.
5. In freehand sawing, use one hand to guide the work and the other to push it into the saw.

6. In ripping to accurate widths, use the ripping fence; and in making square or miter cuts, use the miter gage.
7. Plan the work, if possible, so that it will not be necessary to back the saw out of the cut.
8. Keep the upper guide set down close to the top of the work, particularly when sawing thick material.
9. In sawing irregular work, saw as near the line as possible the first time through. If necessary, make a second cut to finish certain parts.
10. Tilt the table for cutting bevels.
11. In cutting several pieces to the same length, the ripping fence may be used as a gage. This is permissible on a band saw because, the blade being narrow and the direction of travel being straight down against the table, there is no danger of catching the work between the blade and the fence and throwing it as with a circular saw.
12. If the blade tends to lead off to one side, it may be dull or unevenly set, or the guides may be improperly set. This tendency may be counteracted in freehand sawing by shifting the work slightly to one side as it is fed into the saw. This should be considered as a temporary expedient, however, and the cause of the trouble should be determined and eliminated, conditioning or replacing the blade if necessary.
13. If the teeth on one side are set a little more than those on the other, the set may generally be evened by holding an oilstone lightly against the side of the blade while it is running.

Selecting blades Wood-cutting band-saw blades differ principally in the number of teeth per inch, and in the width. Fine-toothed blades make smoother cuts than coarse ones, but saw slower. Narrow blades can be used for sawing sharper curves, but it is more difficult to saw a straight line with a narrow blade than with a wide one. Blades used on saws for farm shopwork commonly range from ⅛ to ¾ in. in width, and have from five to seven teeth per inch.

Adjusting the blade A blade requires adjustment when it is put on the machine. There are four principal adjustments: a tension adjustment on the top wheel, which controls the tension on the blade; a tilting adjustment on the top wheel, which controls the tracking or the centering of the blade on the faces of the wheels; and the adjustment

of each of the two guides. A general procedure for making these adjustments is as follows.

With the blade guides backed off so that they do not touch the blade, make a preliminary adjustment of the tension. Next, adjust the tilt of the top wheel to make the blade run in the center of the wheel faces. Then complete the adjustment of the tension. The tension

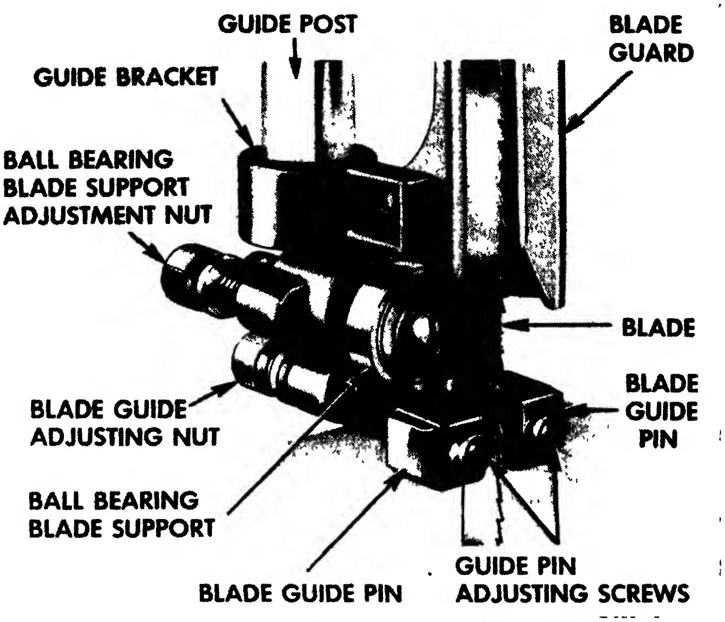


Fig. 4.25. Set the roller supports at the back of the blade and the guide pins at the sides so that they almost, but not quite, touch the blade when it is running free. One blade guide is above the table and another is below it. (Delta Power Tool Division, Rockwell Manufacturing Company)

should be tight enough to keep the blade running true, yet not so tight as to overstrain it.

After the tension adjustment is made and a test run shows that the blade tracks or centers on the faces of the wheels, stop the saw and carefully move the guides up and set them. Set the rollers at the back edge of the blade so that they almost, but not quite, touch the blade when it is running free. The rollers should bear against the blade only when it is actually cutting. Set the guides at the sides of the blade likewise so that they almost, but not quite, touch when the saw is running free.

Cutting metal on a band saw Metal may be sawed on a band saw by using a metal-cutting blade and running it at a suitable speed—much, much slower than the speed of a wood-cutting blade. Metal-cutting blades have finer teeth than wood-cutting blades, commonly ranging from 10 to 24 teeth per inch, and they are especially hardened and tempered for cutting metal. Some band saws have suitable speed-change gears and pulleys so that they may be used to cut either wood or metal, while some are designed for cutting metal only, and others for cutting wood only.

Three-wheel band saws A three-wheel band saw (see Fig. 4-26), as its name implies, has three wheels instead of two over which the

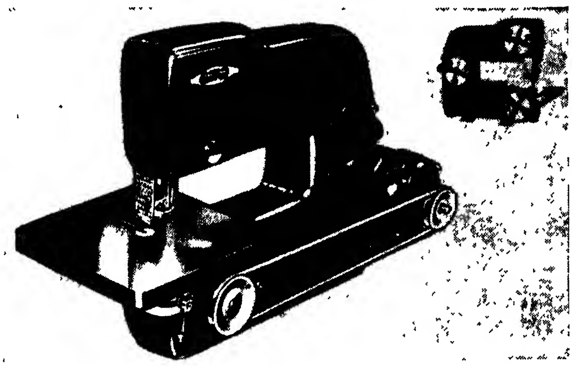


Fig. 4-26. A three-wheel band saw. (Sears, Roebuck and Company)

saw blade runs. The wheels are smaller in diameter, and the three-wheel design makes possible a small, compact machine, yet without sacrifice of throat capacity. It is used and operated in the same general manner as a regular two-wheel band saw.

It is true that a saw blade has to bend to a sharper curve in operating on a three-wheel band saw than on a two-wheel saw. This should not prove to be a serious objection, however, if high-quality blades are used, and particularly if the saw is to be used for intermittent or light-duty work, as would be the case in farm shopwork.

JOBS AND PROJECTS

1. Examine a circular saw and see if its various parts are in proper adjustment, including the ripping fence, the miter gage, the ripping-width scale, the depth-of-cut scale, and the tilt stops and scale.

Make test cuts on small pieces, and check them with square and rule. Make such readjustments as are needed.

2. Make a push stick for safely pushing narrow stock across the saw table.

3. Make a jig of ripping tapers on the circular saw.

4. Study a catalogue and make a list of desirable accessories for a circular saw, such as a dado head and a molding head and cutters. Specify sizes to fit a particular saw.

5. Examine and study other power woodworking saws that are available in the shop, such as the portable electric saw, the band saw, or the radial-arm saw. Systematically examine the various adjustments and be sure you understand how to make them properly. Refer to operating manuals, textbooks, or other suitable source materials. Check particularly on safe operating practices.

6. Make practice cuts in scrap lumber until you can operate power saws and do accurate work. Always follow safe practices. Refer to the text, the operators' manuals, or other suitable sources of information.

7. Select one or two farm appliances, made principally of wood, which you need, such as a poultry feeder, hog feeder, pig brooder, loading chute, animal crate, workbench, or lawn chairs, and make them, using power saws where practical. In selecting plans for such appliances, look through shop books, manuals, bulletins, or farm papers. If available plans do not exactly suit you, modify them slightly to make them better meet your needs. Study the plans carefully and make sure you understand them before actually starting work on the projects.

5 THE JOINTER

1. Adjusting the Jointer
2. Using the Jointer
3. Sharpening and Adjusting Jointer Knives

THE JOINTER is used for smoothing and straightening the surfaces of boards, for cutting rabbets and bevels, and, to a limited extent, for other special work such as the planing of tapers. The jointer does its work by making a series of short cuts with knives mounted in a rapidly revolving cylindrical cutter head. The jointer has two tables, a front and a rear, with the cutter head mounted in between. The tips of the knives come just even with the level of the rear table. The front table is set lower than the rear one by a small

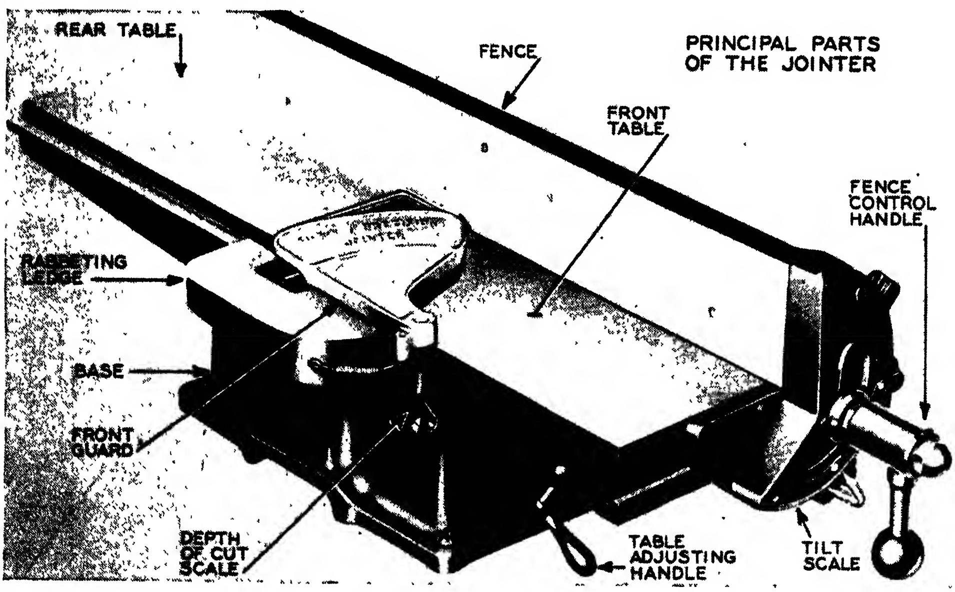


Fig. 5-1. The jointer is used principally for smoothing and straightening surfaces and for cutting rabbets and bevels. (Delta Power Tool Division, Rockwell Manufacturing Company)

amount which determines the depth of cut. A fence guides the stock as it is pushed over the jointer.

The size of a jointer is designated by the length of the cutting knives, or by the maximum width of board it can surface. Jointers used in school and farm shops are usually of the 6-in. size. Such jointers commonly use ½- or ¾-hp motors, and 8-in. jointers are commonly operated with ¾- or 1-hp motors.

Jointers, like other power woodworking machines, can be quite dangerous, particularly if operated by careless or inexperienced workmen. Therefore, before attempting to operate a jointer, study it carefully to learn its various adjustments and controls and safe methods of operation. These are described in the following pages.

1. ADJUSTING THE JOINTER

To do satisfactory work, a jointer must be in practically perfect adjustment, and the knives must be sharp. Sharpening the knives and setting them in the cutter head requires very careful work as well as time and patience. Extreme care should therefore be taken not to plane dirty or gritty lumber or lumber with nails or nail holes (a nail hole might contain a broken nail or grit). Striking a nail would instantly nick the blades and make it impossible to do good work until the knives are reground and reset.

Adjusting the rear table The rear table must be exactly level with the cutting edges of the knives when they are at their topmost position.

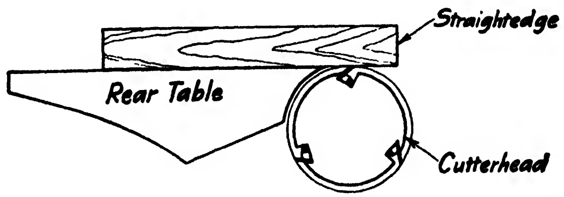


Fig. 5-2. Adjust the rear table and the knives so that the table is level with the cutting edges when the knives are in their topmost position.

To adjust the height of the rear table, place a straightedge about 12 inches long on the table and allow it to extend out over the cutter head (see Fig. 5-2). Loosen the lock on the adjusting screw and raise or lower the table until the straightedge just barely touches the knives

when they come to their highest position. With one knife up, slide the straightedge sidewise and check it at both ends and in the middle. If it is too high or too low, loosen the knife-holding screws just a little and tap the knife down or pry it up as may be required to make it just touch the straightedge throughout its length. Then tighten the holding screws securely. Repeat with each of the other knives.

Adjusting the depth-of-cut scale The scale which indicates the depth of cut is located on the side of the machine. To check and adjust this scale, lower the front table until the jointer takes a cut of exactly a certain depth, say ⅛ in. Then set the pointer to the ⅛-in. mark on the scale, or, on some machines, move the scale to align the mark to the pointer. The pointer or scale will require slight readjustment each time the knives are sharpened or adjusted.

Making adjustments of the fence and fence-tilt scale Most jointers have stops for quickly and accurately setting the fence perpendicular to the table, and also for setting it at the 45-deg position either to the

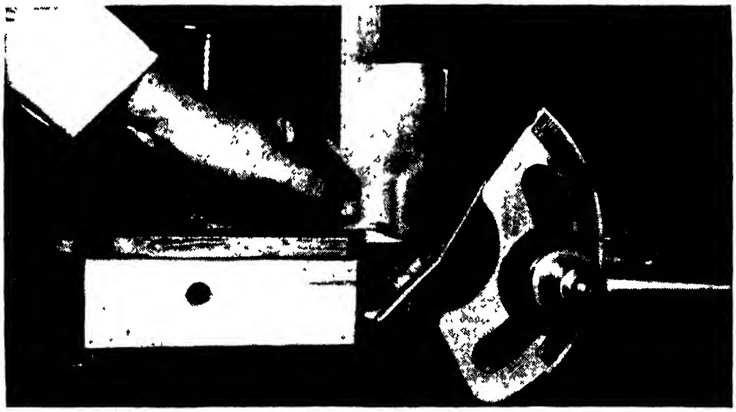


Fig. 5-3. Set the fence square with the table, and then set the pointer on the tilt scale to zero.

left or to the right. To check and adjust these stops, and also the tilt scale, processed as follows: Set the fence exactly perpendicular to the table, using a square as shown in Fig. 5-3. Adjust the stop one way or the other as may be required. When the desired setting is made, tighten the adjustment, and then set the pointer on the tilt scale to zero.

If stops are provided for the 45-deg positions, they may be checked and adjusted in a similar manner. Simply set the fence with a com-

bination square, bevel, or other suitable tool or gage, and adjust the stop as may be required to give an accurate setting.

2. USING THE JOINTER

Before using a jointer, be sure that you understand its various adjustments and controls, and that you understand how to use it safely.

Jointing edges Jointing an edge means making it smooth, straight, and square with an adjacent surface. This is the simplest and most common operation done on a jointer. With the fence set square and the front table lowered for a suitable depth of cut, usually not over ⅛ in., the board is simply held down against the front table and over against the fence while it is pushed slowly forward over the cutter head. To ensure the most satisfactory work, it is well to keep the following points in mind:

1. Where possible, joint with the grain (see Fig. 5-4).
2. Where there is a choice, place the best side of the work against the fence.

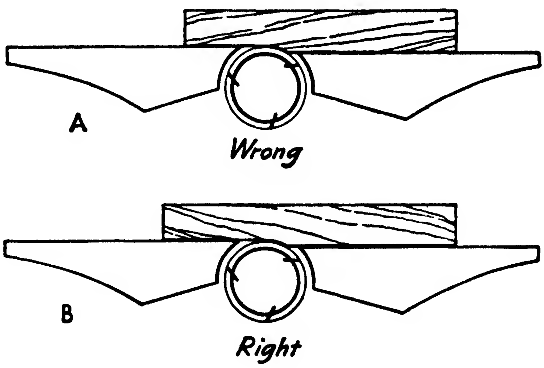


Fig. 5-4. Wherever possible, joint with the grain.

3. Be sure to hold the work down firmly against the front table during the first part of the cut, and also firmly against the fence.
4. When the work has advanced several inches onto the rear table, shift the pressure from the front to the rear table, usually from the right to the left hand. The hand on the work over the front table should then exert no down pressure, but simply push the work forward. Use both hands to exert side pressure to keep the work firmly against the fence.

5. Always keep the hands away from the knives when the jointer is in operation.
6. Whenever possible, keep the guard in place.
7. If a considerable amount of jointing of wide boards is to be done, it may be advisable to screw an auxiliary high fence (made from a wide board) to the regular fence.
8. Where possible, avoid surfacing or jointing pieces that are shorter than 8 to 10 in. in length. Where several short pieces are needed, surface or joint a long piece of stock, and then saw it into the short lengths needed.

Jointing end grain Never joint the end grain of stock less than 8 in. wide without using some kind of jig to hold it as it is advanced over the knives. Narrower stock is liable to be caught by the knives and kicked back out of control.

Jointing end grain is done in much the same manner as jointing the edge of a board, except that only very light cuts should be taken.

There is always danger of some splintering at the finish of an end-grain cut. A good method of avoiding this is to cut part way across the end and then reverse the work and finish the cut from the other edge.

If a piece is to be jointed on both the ends and the edges, always joint the ends first and then the edges. Any light splintering caused at the finish of the end cuts will then be removed when the edges are jointed.

Planing or surfacing Planing or smoothing a broad surface with a jointer is a rather difficult operation. A few of the main points to be observed are as follows:

1. Take light cuts, usually not over $\frac{1}{32}$ in. deep.
2. A hold-down block is very useful in planing, and should always be used in working thin stock.
3. If much thin stock is to be planed, it may be advisable to install an auxiliary wood fence which extends down against the rear table. Thin stock sometimes slides under the regular fence.
4. Work with the guard in place whenever possible.
5. Never press a board down with the hands directly over the cutter head. In case of a kickback, the work might be thrown clear of the

machine, allowing the hand or fingers to go down into contact with the knives.

Cutting bevels on the jointer Cutting a bevel is done much like the jointing of an edge, except, of course, that the fence is tilted in or out to the desired angle. Several cuts are usually required to pro-

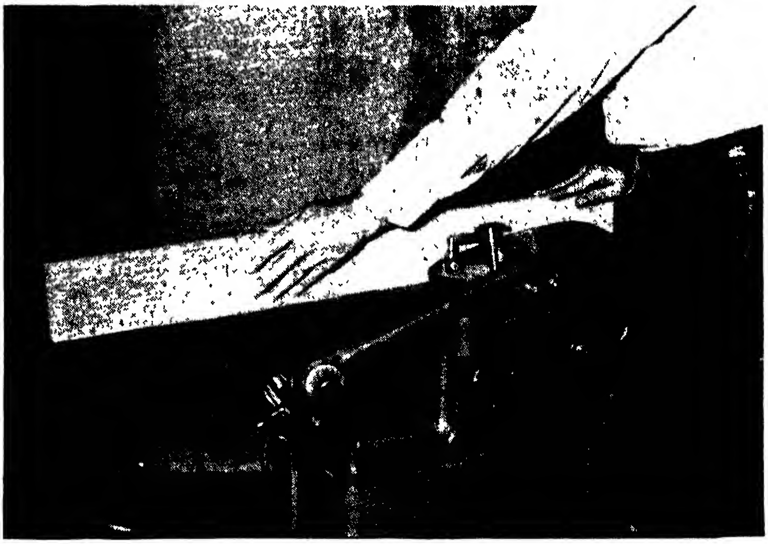


Fig. 5-5. Hold the work down firmly against the front table during the first part of the cut, and also firmly against the fence. After the work has advanced well onto the rear table, shift the pressure from the front to the rear table. Always keep the hands away from the knives.

duce a full-width bevel. As in all jointing work, the stock must be held firmly down against the table and firmly against the fence.

Cutting rabbets on the jointer Rabbets are easily cut on a jointer. Move the fence far to the left so as to expose only a short length of the knives, just enough to give the rabbet the desired width, and lock it in place. Set the front table for a fairly deep cut, and pass the stock over the jointer as many times as required to give the rabbet the desired depth. Shallow rabbets can be made in one cut. On some jointers it is necessary to remove the guard while rabbeting. If the guard is removed, be sure to replace it when the job is done.

Planing tapers Planing of short tapers—shorter than the length of the front table—can be done easily on the jointer. Simply set the

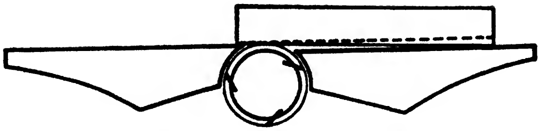


Fig. 5-6. To plane a taper on a short piece, set the front table for a depth of cut equal to the desired taper, up to 1/8 in. Then with the rear end of the work on the front table, lower the front end down against the rear table and start the cut.

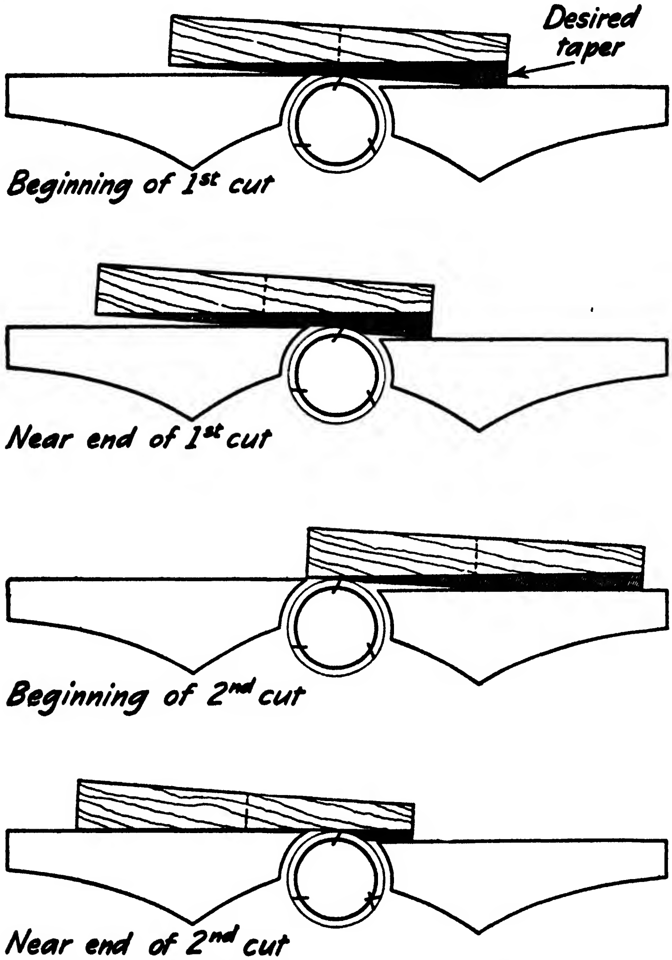


Fig. 5-7. Steps in planing a taper on a long piece.

front table for a depth of cut equal to the desired taper, up to ⅛ in. Then start the jointer and place the rear end of the work down on the front table, and lower the front end of the work down against the cutter head at the point where the taper is to begin (see Fig. 5-6). Feed the work over the jointer, and the taper will be cut. If a taper

of more than ⅛ in. is to be cut, run the work over the jointer as many times as are required.

Long tapers can be cut on the jointer by dividing the length of the board into a number of equal parts which do not exceed the length of the front table (see Fig. 5-7). For example, if a taper is to be cut on a board 28 in. long on a jointer with a front table 14 in. long, mark the board into two 14 in. lengths. Set the depth of cut equal to one-half the total desired taper. Then cut a taper on one end of the board in the same manner as on a short board, but beginning the cut at the mid-point and working toward the end. Finally, take a second cut, beginning at the far end and working along the entire length of the board.

A 36-in. taper can be cut in a similar manner, by first marking off three 12-in. lengths, and cutting the taper in three steps. The depth of cut would be set equal to one-third the width of the taper, and the first cut would be 12 in. long, the second one 24 in. long, and the third one the full length of 36 in.

3. SHARPENING AND ADJUSTING JOINTER KNIVES

After slight dulling, the edges of jointer knives may be restored by honing them in place with a fine carborundum stone. Several light honings can be made before the knives will need to be removed and ground.

Honing the knives To hone the knives, wrap paper around the stone, leaving an inch or two exposed on the end, and place it on the front table of the jointer. The paper is to prevent the stone from scratching the table. Then turn the cutter head until the stone rests flat against the bevel of one knife (see Fig. 5-8). Hold the head in this position while making a few strokes with the stone. Move the stone lengthwise of the knife, counting the number of strokes. Then turn the cutter head and hone the other knives, giving each one the same number of strokes. On some jointers, the head may be held in position during the honing by clamping the drive belt to the frame or by wedging a block against the belt or a pulley.

Jointing the knives The knives can be sharpened and trued by jointing while on the machine. To do this, place the stone, partly

wrapped in paper, on the rear table against a stop block clamped to the front table as shown in Fig. 5-9. Raise the rear table until the stone completely clears the knives. Then with the machine running, gradually lower the table until the stone barely touches the knives. Move the stone across the table to joint the knives over their full length. Remove no more metal than absolutely necessary. The knives may be

Fig. 5-8. After slight dulling, the jointer knives may be sharpened by honing with a fine carborundum stone.

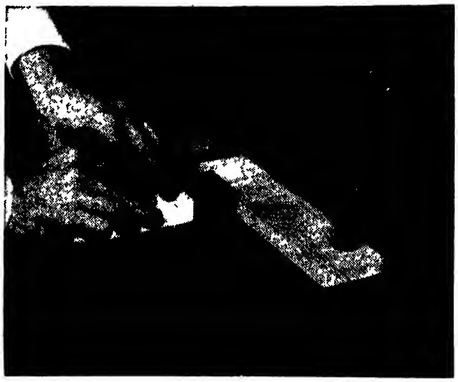


Fig. 5-9. Jointing the knives on the machine.

sharpened only once or twice by jointing before it will be necessary to remove them for a complete grinding, in order to restore the original bevel and back clearance.

Grinding the knives If the knives become nicked or extremely dull, or if the original bevel and back clearance have been destroyed by honing or jointing, then it will be necessary to remove them and grind them.

A good method of grinding the knives is shown in Fig. 5-10. They are held in a groove sawed in the edge of a block. The kerf made by a power saw is usually about the right width for a snug fit. Any looseness may be taken up by means of screws at the ends of the block. This block which holds the knives is moved along against a guide block clamped to the work rest of the grinder.

It is very important that the work rest be adjusted to grind the knives at the original bevel, usually 36 deg. In case the work rest cannot be tilted to the required angle, an alternate method, shown in Fig. 5-10, may be used.

It is very important also that extremely light grinding cuts be taken. The knives are usually high-speed steel and are ground dry, and a heavy cut would quickly overheat and ruin a knife. Two or three light cuts are usually all that are required to bring a knife to a perfect edge.

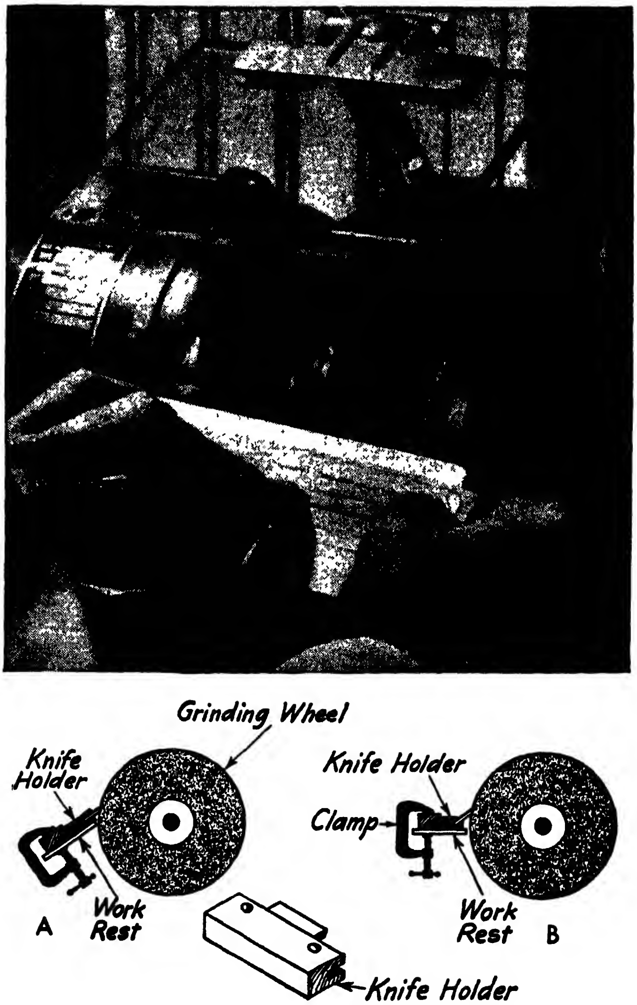


Fig. 5-10. A good method of grinding jointer knives. In case the work rest on the grinder cannot be tilted to the desired angle, the slot in the knife holder may be cut at an angle as shown at *B*.

Once the setup is made on the grinder, take a very light cut on each of the knives, working them in turn. Then paste a strip of paper on the edge of the guide block which is clamped to the work rest, and take another very light cut of each of the knives. In a similar manner,

take another very light cut or two as may be required, working each of the knives in turn.

After grinding, the knives may be honed lightly and carefully on a fine oilstone to remove the fine burr or wire edge.

Setting jointer knives After the knives have been ground, they must be carefully and accurately reset in the cutter head. An excellent method of doing this is with a magnet, as shown in Fig. 5-11 and described in the following steps:

1. Clamp a stop block to the front table parallel to the end of the table and back about an inch from the cutter head.
2. Mount the knives firmly but not too tightly in the grooves of the cutter head, so that they project about ⅟16 in. Measure from the surface of the cutter head to the rear edges of the bevels.

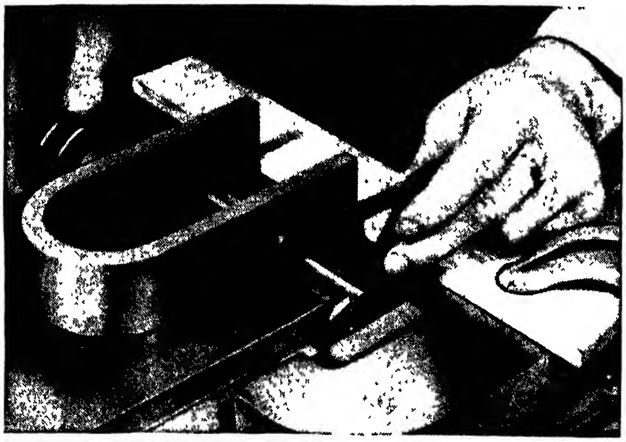


Fig. 5-11. Setting a knife in the cutter head with the aid of a magnet. (Delta Power Tool Division, Rockwell Manufacturing Company)

3. Place the magnet down on the rear table, with its ends resting against the stop block, and adjust the height of the rear table if necessary until the magnet just touches the cutting edge of one knife when it is turned to its highest position.
4. Scribe a mark on the magnet exactly in line with the cutting edge of the knife.
5. Now loosen the knife-clamping screws and allow the magnet to hold the knife up in place while you retighten the screws.

6. Revolve the cutter head to bring each of the other knives up, in turn, to the line on the magnet, and set them in exactly the same manner.

Points on safety in using jointers

1. Keep the floor around the jointer clean and free of scraps and rubbish.
2. Stand to one side when using the jointer. Do not stand directly in line with the tables, where you might be hit in case of a kickback. Also, see that others in the shop are not in line with the jointer when it is in use.
3. Keep the guard in place whenever possible.
4. Keep your eyes on the work, and keep your hands away from the knives as far as possible.
5. Keep the knives sharp and properly adjusted. Dull knives are more likely to cause kickbacks.
6. Do not take cuts that are too deep.
7. Do not move the fence while the machine is in operation.
8. Feed the work so that the knives cut with the grain—not against it.
9. Do not run short pieces over the jointer. Pieces shorter than 8 or 10 in. are very difficult to hold safely.
10. Surface or joint only material that is sound. An unsound piece with knots or splits may break and be thrown.
11. A hold-down block is useful in surfacing and should always be used in planing thin stock.

JOBS AND PROJECTS

1. Examine a jointer and check its various adjustments, including the height of the rear table, the depth-of-cut scale, the fence stops, and the fence-tilt scale. If any of these adjustments are off, make adjustments and recheck. Test the adjustments by doing some work on test pieces and checking with square, rule, or other suitable tools.

2. Use the jointer in the construction of woodwork projects in the shop, where it can be used to better advantage than hand tools or other power tools. Always operate the jointer in a safe manner. Refer to the text, the operator's manual, or other suitable sources for information on safe operating practices.

3. After the jointer knives have become slightly dull, hone them in place in the cutter head, using an oilstone. Study the process carefully before starting.

4. After considerable use, or after slight nicking of the knives, joint them in place in the cutter head. It is best for the beginner to perform this operation under the close supervision of the instructor or an experienced mechanic.

5. Make a jig for grinding jointer knives on a regular shop grinding wheel.

6. Remove the knives from a jointer, grind them, hone them, and replace and set them in the cutter head. (This requires very precise and careful work and should be undertaken only by those who are reasonably skilled in shopwork.)

6 PAINTING, FINISHING AND WINDOW GLAZING

1. Inspecting Buildings for Painting Failures
2. Selecting Paints
3. Preparing Outside Wood Surfaces for Painting
4. Applying Outside Paint
5. Using Stains, Varnishes, Enamels, and Lacquers
6. Painting Metal Surfaces
7. Whitewashing
8. Selecting, Cleaning, and Caring for Brushes
9. Storing and Handling Paints Safely
10. Glazing and Repairing Windows

IT IS practical for a farmer to paint his smaller buildings and many pieces of farm equipment himself and, under many conditions, his larger buildings also. Painting prolongs the serviceable life of materials, improves appearance, and, on the inside of buildings, promotes cleanliness and sanitation.

Oil-base paint is composed of a pigment, such as white lead, zinc oxide, and titanium dioxide, and oils, such as linseed oil and soy bean oil. The oils are often referred to as a *vehicle*. Under many conditions a thinner like turpentine is added to make the paint spread more easily and penetrate better, and a drier is added to make it dry more rapidly. Upon drying, the oils form a tough, somewhat elastic film that binds the particles of pigment together and to the surface being painted.

A good outside paint job, as it weathers, becomes chalky on the surface and wears down gradually, leaving a protective coat on the surface for years. The ultraviolet rays in sunshine attack the oil in the paint,

gradually destroying it, and leaving the particles of pigment to dust or chalk off. For maximum wearing results, it is important that the proper proportion of pigment and oil be used in the finish coat. Excessive thinning of the final coat (too much oil) may cause unduly rapid chalking, because there is not enough pigment in the film to protect the oil adequately from ultraviolet rays. Too much pigment, or not enough oil, may also cause rapid chalking, because there is not enough oil in the paint film to bind the particles of pigment together.

1. INSPECTING BUILDINGS FOR PAINTING FAILURES

A knowledge of painting troubles and failures and of their causes is valuable to anyone planning to do painting. It will enable him to better select paint for particular jobs and to apply it with reasonable assurance of good results.

Structural defects in a building frequently cause early failure of paint by allowing moisture to get into the inner parts of the walls back of the paint.

Alligatoring The application of a relatively fast-drying coat over one which is too soft may cause alligatoring (see Fig. 6-1). The soft undercoat may be due to the use of too much oil, to the use of unsuitable oil which dries to a soft film, or to insufficient drying time before the next coat is applied.

Blistering and peeling Figures 6-2 and 6-3 show blistering and peeling, which are caused by moisture behind the paint film. It may be from moisture in the wood at the time of painting or from moisture, possibly in the form of vapor, coming through the wall and getting behind the paint. Expansion of this moisture under the paint film, due to a rise in temperature, may cause blisters to form. When such blisters break, the paint will peel.

Checking Checking is the formation of a network of fine hairlines in the outer coat which do not extend through to the undercoats. It results from the natural shrinking of the oil as it changes from a liquid to a solid as the paint ages. It is usually not a serious defect, and it can be avoided by the use of suitable proportions of thinner and oil for the various coats and allowing plenty of time for drying between coats.

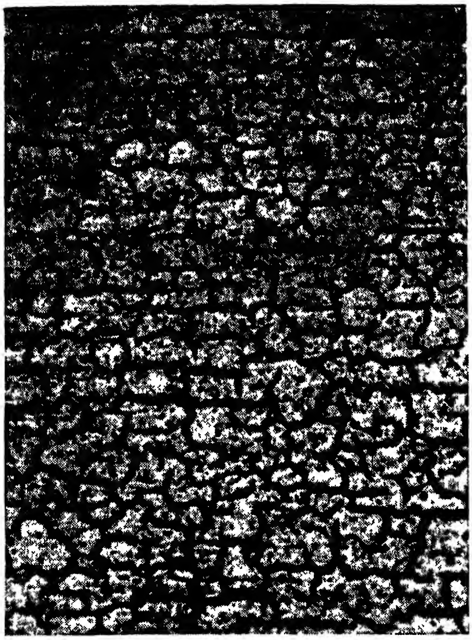


Fig. 6-1. Alligatoring.

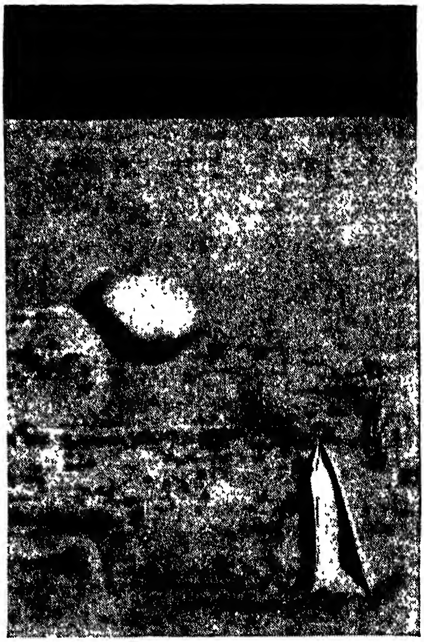


Fig. 6-2. Blistering and peeling.

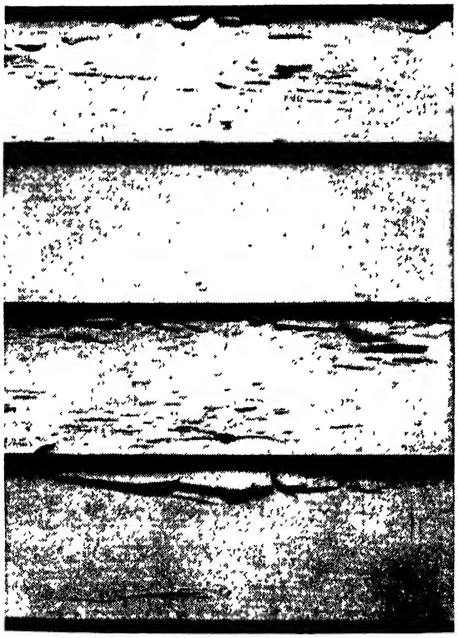


Fig. 6-3. Peeling.

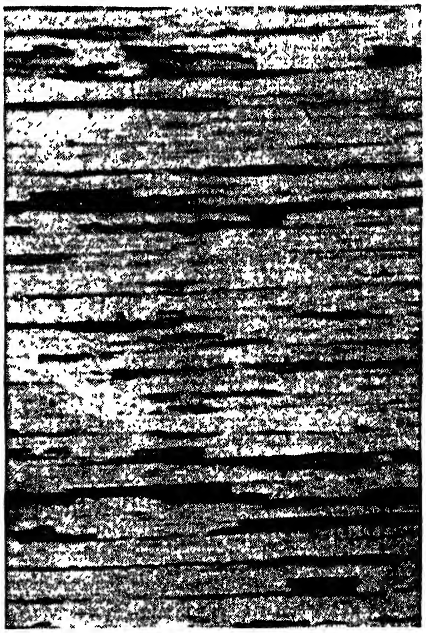


Fig. 6-4. Cracking and scaling.

Cracking and scaling Figure 6-4 shows cracking and scaling. This results when the paint becomes too brittle as it ages. Wood expands and contracts, and if the paint film is not elastic enough to expand and contract with the wood, cracks develop in the paint and it eventually scales off. Cracking and scaling may be avoided by using a higher-grade, more elastic paint. When repainting a cracked or scaled surface, it is necessary to remove the old paint by using scrapers, sandpaper, wire brush, blowtorch and scraper, or liquid paint remover; otherwise only an inferior, rough job will result.

Running and sagging Using a paint with too much oil and applying it too thick is the cause of running and sagging (see Fig. 6-5).

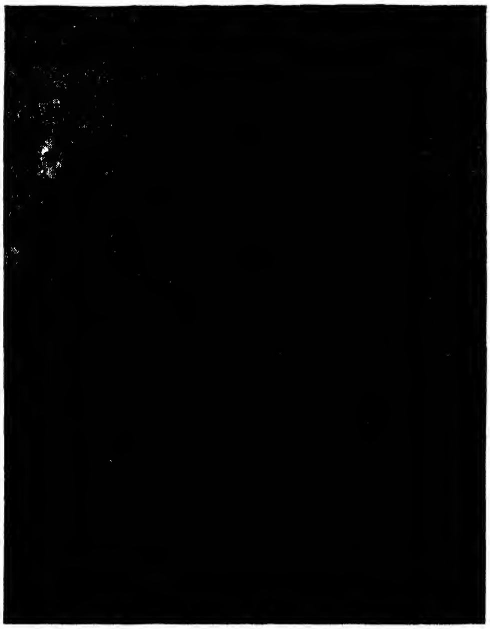


Fig. 6-5. Running and sagging.

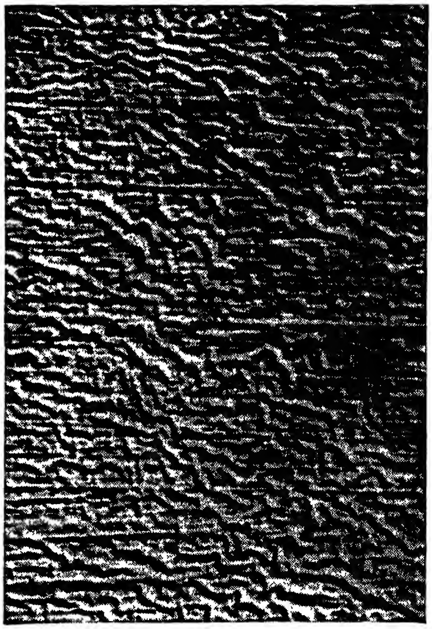


Fig. 6-6. Wrinkling.

Applying paint over a glossy surface may also cause sagging. A glossy surface should be sandpapered or wiped with a cloth soaked in benzine before painting.

Wrinkling Figure 6-6 shows wrinkling, which is caused by improper drying of the paint film. The surface dries quickly, leaving undried paint underneath. Using too much oil, failure to brush the paint

out to a thin, even coat, or a sudden drop in temperature during the drying period may cause improper drying, resulting in wrinkling. Sand wrinkled surfaces before repainting.

2. SELECTING PAINTS

Improvements are continually being made in the materials used and in methods of compounding and making paints. Most large paint manufacturers have research departments to develop and test new products under various conditions. It is therefore usually best to select paints made by a reputable manufacturer, and to apply them carefully in accordance with the instructions printed on the labels.

Selecting outside house paints Ready-mixed paints are recommended for farm painting jobs. Lead and oil paints mixed on the job were formerly widely used, but are now used infrequently, owing to the improvement in ready-mixed paints and to the economies afforded by expert compounding and mixing at the factory.

Most manufacturers make two or more grades of house paint. It is nearly always more satisfactory and cheaper in the end to buy the best grade, although for some purposes, such as for temporary protection, a second-grade paint may be advisable. Avoid third-grade paints. The biggest item of painting expense is generally labor. Therefore, even if the cost of paint is reduced by using a cheaper paint, only a little saving may be made in the total cost of a paint job. Inferior paints do not cover as well, and considerably more is required, offsetting to a large degree the lower price per gallon. Furthermore, the period of protection afforded by inferior paints is much shorter. All things considered, the use of inferior paints is generally false economy.

The difference in quality of paints is due principally to the kinds and amounts of various ingredients in the pigment and in the vehicle. The labels on the containers state the composition of the paints. The dealer can help interpret these labels and recommend particular grades of paints for specific jobs.

Selecting barn paints To meet the demand for special paints for barns, fences, and outbuildings, paint manufacturers have made special paints compounded from metallic oxides, such as iron oxide. These paints are of darker colors, principally red, and cost less per gallon than

house paints. They may be satisfactory in durability and appearance for the purpose intended, particularly where labor costs for painting are low. For greatest durability and best possible appearance, however, regular house paints should be used. Painting all buildings on the farmstead white or some light color gives a very good appearance. Gray is often a favorite color. It does not show soil and dirt like white, and is much more attractive than the reds and browns formerly used extensively for barns and outbuildings.

Selecting interior paints Several kinds of paints are available for use on interior walls and ceilings, ranging from high-quality oil paints to low-cost water paints. Oil paints, which are of flat, semigloss, or high-gloss finish, are easier to clean and to paint over when redecoration is needed. Casein paints, which are made by mixing casein powder with water, gives a satisfactory low-cost finish, which may be washed and which is somewhat better than that provided by calcimine paints.

The choice of paints for inside walls and ceilings is usually a problem of balancing the results desired against the costs. It is usually best to use higher-quality paints for best results over a period of years, although the cheaper paints give satisfactory results for shorter periods. The cheaper water paints are often used for basements and recreation rooms in preference to whitewash. Consulting with paint dealers and others who have had experience with different kinds of paints is helpful in making a choice.

Selecting paints for concrete, stucco, and brickwork Concrete, stucco, and brickwork may be painted with cement-base paints or with oil-base paints. The cement-base paints are in powder form and contain a high percentage of cement, along with waterproofing materials. They are prepared for use by mixing with water. They are economical and easily applied. It is important that the surfaces to be painted be clean and in good condition, and that the paint be well brushed in with a stiff short-bristle brush.

Regular oil-base paints, such as house paints, can be used on masonry, provided a nonpenetrating sealing or priming coat is first applied to seal the pores of the surface. Oil-base paints which require no priming or sealing coat are also available. These have materials in them which seal the surface. Masonry paints may be expected to give satisfactory results if they are bought from reputable paint suppliers and are carefully applied according to the directions printed on the containers.

Estimating the amount of paint required To estimate the amount of paint required for a job, determine approximately the number of square feet to be covered, and then divide by the number of square feet a gallon of paint is estimated to cover. To estimate the outside area of a building, measure the distance around the building and multiply by the wall height, not including the gables. Figure the area of the gables by multiplying the base by one-half the height, and add the result to the wall area.

The area which a gallon of paint will cover depends upon the paint, the condition of the surface, and whether it is the first, second, or third coat. Under average conditions, 1 gal of outside house paint will cover about 600 sq ft on the first coat on new wood, and about 700 sq ft on the second and third coats. On repaint jobs with the surface in good condition, 1 gal of good paint may be expected to cover 400 to 500 sq ft with two coats.

Two coats are usually enough for previously painted surfaces where the old paint is in reasonably good condition. Three coats are generally recommended on new wood.

It is better to buy a little more paint than the minimum estimated as needed, for it is better to have a little left over than to run short.

3. PREPARING OUTSIDE WOOD SURFACES FOR PAINTING

Surfaces to be painted should be dry and clean, that is, free from mud, dust, grease, plaster, smoke, rust, or old, loose, scaly paint. Usually a wire brush, a putty knife, and a dusting cloth or brush are the only tools needed for cleaning. Sometimes a surface will need to be washed, or, if greasy, wiped with a cloth moistened with turpentine or gasoline, and then allowed to dry. Sandpaper can sometimes be used to advantage on a rough surface. If old, cracked, scaly paint must be removed, it may be necessary to use a blowtorch or a liquid paint remover.

Replace any broken or rotten boards, and nail down any loose ones. Inspect the building carefully for any evidence of paint failure due to moisture getting under the paint. Repair any leaks or defects that might admit moisture. Putty or calking compound may be needed

around window frames or other places to fill cracks and seal against moisture.

4. APPLYING OUTSIDE PAINT

Choosing suitable weather Paint when the weather is good for drying and when there is little or no wind or dust. Avoid times when insects may bother you. Be sure the surface is dry. Early summer is usually the best time to paint, although good results may be obtained in both spring and fall if care is taken not to paint over damp surfaces.

Fig. 6-7. Thoroughly mix factory-prepared paint before applying it.

Temperatures between 65 and 80° are best; painting should usually not be done when the temperature is below 50°.

Thinning paint When ready-mixed paints are used, all coats except the last require thinning. Directions for thinning are printed on the label; follow these directions carefully, because the success and life of a paint job depend upon the proportions of pigment and oil.

It is very important that the paint be thoroughly mixed. Pour the liquid off the top of the can into a clean container, and add any thinners that may be required. Stir the thick pigment into a smooth paste,

using a stiff flat paddle. As the stirring proceeds, slowly add the liquids. "Boxing," or pouring the paint back and forth from one container to another, ensures better mixing. A paint-stirring rod driven by a small electric drill, if available, saves time and labor in mixing. To do a good job of mixing 5 gal of paint by hand may require as much as a half-hour.

Painting with a brush Hold the brush lightly with the long part of the handle resting in the hollow between the thumb and first finger and with the ends of the fingers well up on the ferrule (see Fig. 6-8). Do not allow the fingers to extend down on the bristles.

Dip the brush into the paint about one-third the length of the bristles, and then remove the excess paint by gently tapping the brush against the inside of the pail, or by wiping it over the edge. Use long sweeping strokes. *Feather* the strokes by bringing the brush down against the surface gradually at the beginning of each stroke and lifting it gradually at the end. Brush the paint out well to form an even coating.

Start at the top of a surface and at one edge, working across and down. Try to finish a day's work at a corner of the building or at a window. In this way the place where you finish one day's work and begin another will then usually not be noticeable, even though there is a lapse of several days before painting is resumed.

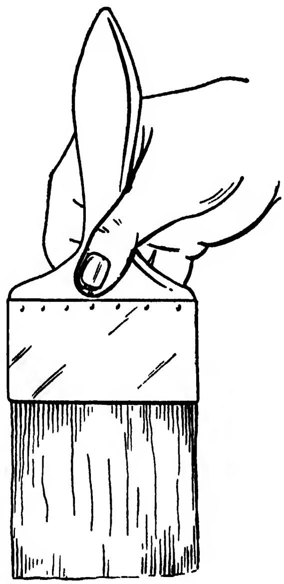


Fig. 6-8. A good way to hold a paintbrush. The ends of the fingers should be well up on the ferrule and should not touch the bristles.

Painting with a spray gun Spray painting saves a large amount of labor, especially when large surfaces with few windows and doors are to be painted. It is particularly good for painting concrete, brick, wood shingles, or rough lumber. Spray painting, properly done, will give as good a job as brush painting, and while it will waste some paint, possibly as much as 5 to 10 percent, a painter can spray up to ten times as much in a day as he could paint with a brush.

A spray-painting outfit consists essentially of an air compressor with an engine or motor to drive it, suitable controls and regulators, and a

paint gun. For painting large buildings it is important to use good equipment of ample capacity. Small outfits, while they are satisfactory for painting small appliances, furniture, or machines, are usually not satisfactory for painting buildings. The gun should be procured from a reliable dealer, and the compressor should maintain an air pressure of at least 60 lb per sq in. The gun should be adjusted to spray the paint without more thinning than would be needed for brush painting.

In painting with a gun, use slow, sweeping strokes, keeping the nozzle 8 to 10 in. from the surface. Have the gun in motion before pulling the trigger, and start releasing it before the end of the stroke. With a little careful practice, one can soon make feathered strokes and satisfactory laps. Strain paint to be applied with a spray gun through very fine screen or cloth.

When work is stopped, be sure to clean the gun thoroughly. This may be done by spraying a suitable solvent, such as paint thinner, painter's naphtha, or benzine, through the gun, and then blowing it clean with compressed air. If work is to be stopped for only an hour or two the gun need not be thoroughly cleaned if it can be submerged in a can of solvent.

5. USING STAINS, VARNISHES, ENAMELS, AND LACQUERS

Staining Stains are used for coloring wood. They are available in a wide variety of colors and are of three general types, based upon the vehicle or carrier used, namely, water stains, alcohol or spirit stains, and oil stains. Oil stains, although usually more expensive, are probably the most satisfactory for general use. They are easily applied and do not raise the grain like water or spirit stains. An application of linseed oil alone makes a very desirable light-color stain.

Varnishing A varnished finish makes a very attractive appearance and has good wearing qualities. The best varnishes are made of copal gum dissolved in linseed oil and turpentine. There are various grades and kinds of varnishes on the market, and to ensure best results, a varnish should not be used for a purpose for which it is not suited. Interior varnishes cannot be expected to give good results when exposed to the weather. Varnishes should be thinned and applied in accordance with the directions on their containers.

Apply varnish with a high-grade clean brush that has never been used for anything except varnish. Varnish is sticky and slow in drying. Keep dust down to a minimum around freshly varnished surfaces.

Using enamels and lacquers There is on the market a wide variety of enamels and lacquers that are especially suited to finishing inside woodwork and furniture. They are available in various colors, and although the better grades are somewhat expensive, they produce finishes that are attractive and easily cleaned and that last well unless subjected to unusual wear and abuses. Enamels are made by grinding pigments in varnish and should therefore be handled and applied like varnish. Lacquers and quick-drying enamels have more volatile vehicles or solvents and therefore dry more quickly.

6. PAINTING METAL SURFACES

In painting metal surfaces, it is most important to use a priming coat of rust-inhibiting paint, such as red lead and oil. In general, the priming coat may be followed by any paint that will give the desired finish and color. Regular house paints are commonly used on gutters and downspouts after they have been primed.

For painting machinery and implements, inside metal barn equipment, etc., it is best to use a special implement or metal paint or enamel which will dry harder and give a more durable wearing surface. Such metal paints usually have some varnish in them to produce the desired hard-wearing surfaces.

It is important that metal surfaces be thoroughly cleaned of grease, old loose paint, or loose rust before paint is applied.

Metallic zinc paint is very good for rust prevention and is especially satisfactory on zinc or galvanized surfaces. The pigment of such paints should contain about 80 percent of metallic zinc powder.

7. WHITEWASHING

Whitewash is inexpensive and is often used for lightening and improving the appearance of barns, poultry houses, and similar places. It is also sometimes used for painting fences and other outside surfaces, but for such purposes its poor wearing qualities make it much inferior to oil paints.

Common whitewash is composed of lime and water and may be applied either with a brush or with a sprayer. Many different formulas are used for making whitewash. A good general-purpose whitewash may be made as follows: Make a lime paste by soaking 25 lb of hydrated lime in about 3 gal of water. Dissolve 2½ lb of casein glue in water according to the manufacturer's instructions, dilute the mixture to a thin consistency, and mix it thoroughly with the lime paste just before using. Thin it to the desired consistency.

Another good whitewash may be made by mixing 2½ lb of salt, 4½ gal of skim milk, and 50 lb of hydrated lime.

8. SELECTING, CLEANING, AND CARING FOR BRUSHES

Selecting brushes A 3½- or 4-in. brush is commonly used for painting large surfaces. The bristles should not be too long, not much over 4 in., for inexperienced painters. A flat brush 3 in. wide is a good size for painting trim, and a sash brush 1 or 2 in. wide is suitable for painting windows. For varnishing, use a good-quality brush that has never been dipped in paint.

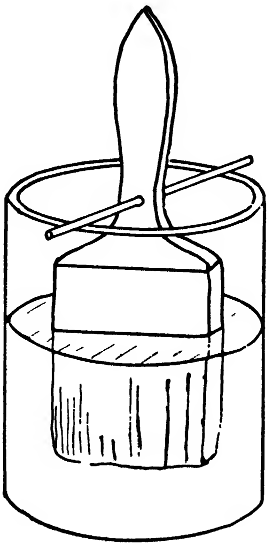


Fig. 6-9. A good way to take care of paintbrushes when work is stopped overnight or for a few days. Note that the bristles are covered with the liquid but do not rest on the bottom of the can.

Taking care of brushes while in use Never allow a brush to rest upright on its bristles. If work is stopped for a few minutes, remove the surplus paint from the brush by wiping it on the edge of the pail, and then lay it flat, across the top of the pail or on some smooth,

clean surface. If the work is stopped for a longer time—overnight or a few days—suspend the brush in a can of turpentine and raw linseed oil in the case of paintbrushes, or in turpentine or paint thinner in the case of varnish brushes. This can best be done by drilling a small hole through the handle and hanging it on a small wire hook on the side of the can, or on a wire laid across the top of the can, so that the bristles are covered by the liquid and yet do not touch the bottom of the can (see Fig. 6-9).

Cleaning and storing brushes When you have finished painting or varnishing, clean the brush out thoroughly with turpentine, benzine, gasoline, or kersosene, and wash it with warm soapsuds. Then shake the brush well, and while it is still damp, wrap it in heavy paper and lay it away or hang it in a dry cool place.

Old, neglected brushes can generally be reclaimed by soaking them in paint remover or special brush cleaners available at paint stores, and then washing them in turpentine, alcohol, gasoline, or benzene.

9. STORING AND HANDLING PAINTS SAFELY

Paints are flammable, as are turpentine, oils, and thinners commonly used for thinning paint and cleaning brushes. Therefore, do not handle or use these materials near an open flame. Oil-soaked and paint-soaked rags sometimes catch fire spontaneously. They should therefore not be left scattered about, but should be kept in a metal container with a tight cover until they can be burned safely.

Store paint, as well as turpentine, paint oils, and thinners, in sealed containers, preferably of metal. Glass containers are subject to breakage, and unsealed cans are subject to evaporation and spilling. A definite, safe place for storage of paint and painting materials contributes not only to safety, but also to orderliness and system about the shop or premises. Left-over paint can be saved for future use if properly sealed and stored.

10. GLAZING AND REPAIRING WINDOWS

The ability to cut glass and repair windows is valuable, as there are occasional accidents requiring replacement of glass; and windows should always be inspected and repaired as needed just before painting.

Cutting glass to size Glass is "cut" by first scratching the surface with a tool called a *glass cutter* and then broken by applying pressure along the scratch. To cut glass, clean it and put it on a flat table or bench. Hold a straightedge firmly on top of the glass to guide the glass cutter, and draw it along slowly with an even, moderate pressure (see Fig. 6-10). Begin at the far edge of the glass, and make a clean scratch all the way across in one stroke. Do not use too much pressure, or the

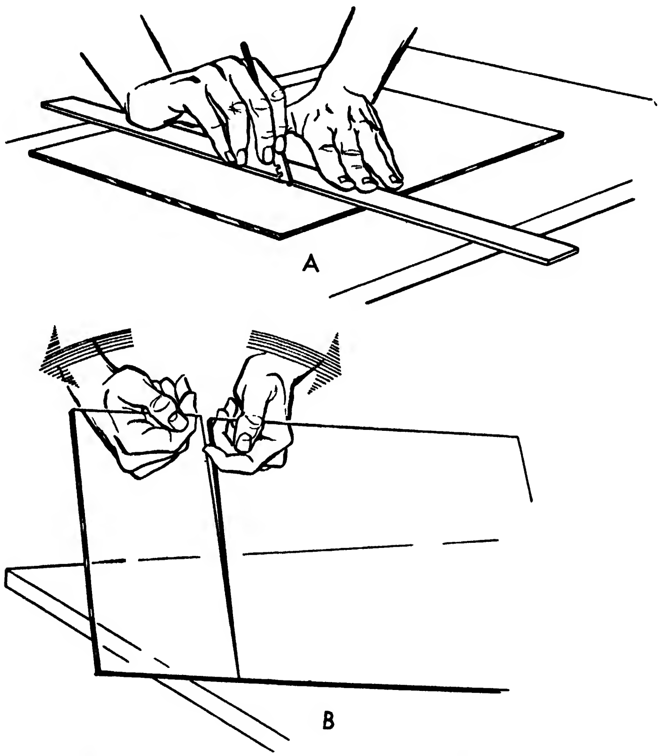


Fig. 6-10. Cutting glass: *A*, draw the glass cutter along the straightedge, using a firm but moderate pressure—do not let the cutter lean sideways; *B*, break the glass by applying pressure with the two hands.

glass may splinter. Do not go over a scratch a second time, as this injures the cutter and may cause the glass to break unevenly. The cutter may be leaned slightly in the direction of cutting, but do not let it lean sideways.

After scratching, break the glass by applying pressure up from beneath the scratch (see Fig. 6-10). Tapping the glass first underneath the scratch with the end of the glass cutter may make the breaking easier and cleaner. If any small jagged projections are left, break them

off with one of the square notches in the end of the glass cutter or with a pair of pliers.

Another method of breaking the glass is to place it, scratched side up, on a flat table with the scratch along one edge and then apply pressure downward on the overhanging part (see Fig. 6-11).

A good way to get a piece of glass cut to exact size is to mark out the size on paper and then place the paper under the glass. The straightedge is then easily placed to guide the cutter exactly where it should go. It is a good plan to cut glass $\frac{1}{16}$ to $\frac{1}{8}$ in. shorter and narrower than the frame into which it is to fit.

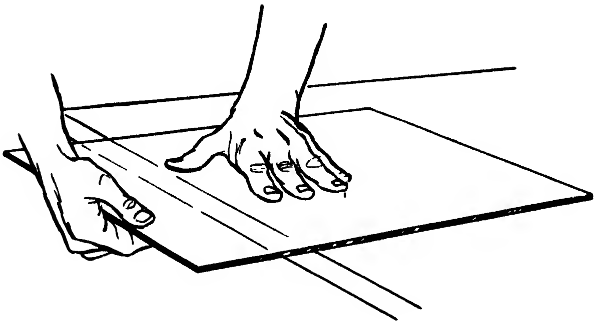


Fig. 6-11. An alternate method of breaking a glass after it is scratched with a glass cutter. Align the scratch over the edge of the bench and press downward on the overhanging portion.

Replacing broken window glass The first step in replacing a broken window is to remove all the old pieces of glass, putty, and glaziers' points (flat triangular or diamond-shaped pieces of metal used to hold the glass in place). Next clean the rabbet (groove) and coat it with linseed oil or thin paint, so that when the new putty is applied it will not dry out too fast. Then put a thin layer of putty in the rabbet and press a new glass of the proper size firmly into place. Drive glaziers' points 6 to 8 in. apart to hold the glass in place. A good way to drive glaziers' points is with a wood chisel. Hold the chisel with the bevel flat against the glass, and tap the points with the edge of the chisel. If desired, the edge of the chisel may be tapped lightly with a hammer. If glaziers' points are not available, use small brads instead.

Finally, seal the glass in place with putty. The putty may be rolled between the hands into a roll about $\frac{1}{2}$ in. in diameter and a few inches long. The roll is then put on the edge of the glass in the rabbet, and pressed and smoothed into place with a putty knife.

Repairing window sash Window sashes often fail at the corners. If loose corners are reinforced with corner irons, as shown in Fig. 6-12, a

window sash may be strengthened and kept in service much longer. If an iron is installed around the outside corner (Fig. 6-12*B*), set it in flush, and countersink and drive the screws carefully so that their heads will be flush or slightly below the surface.

Usually the first step in repairing a window is to remove it from the frame and take it to the shop, where it can be worked on more conveniently. Windows are commonly held in place by window stops lightly nailed with small finish nails. To remove a window, carefully remove the stop at one edge of the window. An old wood chisel or a small pry bar may be used, but be careful not to mar the stop. Removing only one stop will allow the bottom sash of a double-sash

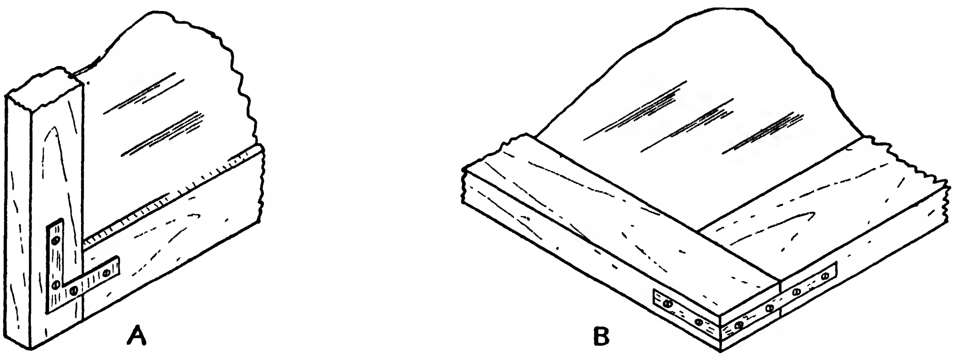


Fig. 6-12. Methods of reinforcing a defective window sash by means of corner irons.

window to be removed. If the upper sash is to be removed, the parting strip must be removed from one side of the window frame or jamb. It is usually held in place with small finish nails and can easily be pried out.

JOBS AND PROJECTS

1. Examine a few buildings for painting defects or troubles, and determine the causes of the troubles, whether moisture in the wood, faulty building construction, improper thinning or mixing of the paint, poor methods of applying the paint, improper selection, etc.

2. Inspect some building, such as a poultry house, garage, barn, or house, and make a list of repair jobs that should be done on windows, siding, roof, or other parts before painting.

3. Estimate the amount of paint and other painting materials that would be required to paint the building you inspected.

4. Make all arrangements for the paints, materials, supplies, and equipment you will need for painting some small building on your home farm, and paint it. Make a statement of all costs of doing the job, allowing yourself a reasonable wage.

5. Thoroughly clean and paint some machine or implement that has been repaired in the shop.

6. Repair some window sash in need of repairs. Remove it and take it to the shop, if feasible, replacing any broken panes, strengthening corners with corner irons or by other means, or doing such other work as may be needed.

7 SHARPENING AND FITTING TOOLS

THE CUTTING EDGE of a sharp knife or similar tool is composed of a series of microscopic teeth. Such tools cut best when used with a diagonal or sawlike motion. The size of the teeth determines whether the edge is known as coarse or fine. For certain kinds of work, coarse edges are best, and for other kinds of work, medium, fine, or very fine edges are required. Bread knives and paring knives work better when sharpened to coarse edges, whereas plane bits and wood chisels need fine edges, and razors still finer edges.

Sharp tools are the mark of a good workman. Only a poor workman or an amateur will struggle along with a dull tool rather than take time to sharpen it, for the time required is soon regained in faster and better work. Furthermore, the sharpening of most common tools

is simple and easy. Those interested in shopwork, therefore, should strive for an early mastery of the technique of sharpening the tools commonly used.

1. SELECTING AND USING GRINDERS AND SHARPENING STONES

A good power-driven grinder can well be the most valuable tool in the shop. Every farm shop should have one if at all possible. It is used for sharpening tools and for the many odd jobs of grinding that arise, such as grinding parts to fit, and grinding hard materials that cannot be easily filed or otherwise shaped. If it is not possible to have a power grinder, a hand-operated one that clamps to the workbench will serve for sharpening tools and for light grinding.

Selecting a power grinder Probably the best type of grinder for the farm shop is a motor grinder with grinding wheels on the ends of the motor shaft. Where some saving in first cost is imperative, a belt-driven grinder with a separate motor may be used. The motor grinder is compact, convenient, and usually more foolproof and trouble-free. It is therefore the preferred type for most shops, and can be depended upon to give satisfactory service under most conditions.

Grinders are classified as to size according to the diameter of the grinding wheels they use, and may also be classified as light-, medium-, or heavy-duty. A 6-in. grinder is the smallest size that should be considered for the farm shop. A 7- or 8-in. grinder would be much better, and in a shop where considerable heavy grinding is done, perhaps in connection with welding, a 10-in. or even a 12-in. grinder might be justified. In many shops where a 10- or 12-in. grinder is used, a smaller 6- or 7-in. grinder could also be used to advantage for tool sharpening and for the lighter grinding jobs.

Six-inch grinders are commonly equipped with $\frac{1}{4}$- or $\frac{1}{3}$-hp motors, and 7-in. grinders with $\frac{1}{3}$- or $\frac{1}{2}$-hp motors. Motor grinders operate at standard motor speeds, either at about 1,725 or 3,450 rpm on 60-cycle current. Smaller grinders usually operate at the higher speed, and the larger ones at the lower speed. Some grinders are available at either speed, depending upon which is ordered. Where there is a choice, the lower speed is usually preferred because there is less likelihood of vibration, although grinders operating at the higher speed grind somewhat faster.

In selecting a grinder of any kind, it is important to get one that is sturdy and well built, with good bearings that are lubricated and sealed for life, or that have adequate provisions for lubrication and for keeping out grit. Only grinders with wheel guards and sturdy adjustable work rests should be considered. Adjustable, shatterproof-glass eye shields are available for most grinders and should be purchased as a part of the original equipment.

Grinders with extended motor-end housings provide extra clearance around the grinding wheel and are desirable, even though a little more expensive.

Where considerable mower-sickle grinding is to be done, it may be advisable to buy a special sickle grinder.

Selecting grinding wheels Always buy good grinding wheels that are suited to the kind of grinding to be done. Abrasives made in the electric furnace are used exclusively in the better wheels. Emery, a mineral found in nature, was once used in grinding wheels, but since it tends to become slick and glazed, resulting in excessive heating during grinding, it is no longer used in good wheels. The two principal abrasives used in grinding wheels are (1) aluminum oxide, used mainly for grinding materials of high tensile strength, like steel, and (2) silicon carbide, used mainly for grinding materials with low tensile strength, like cast iron. Aluminum oxide wheels are used for general grinding in the farm shop.

Choosing grain and grade The coarseness or fineness of a grinding wheel is designated by a number representing the size of grains or particles used in making the wheel. A *grain* of 36, for example, means that the finest screen through which the particles will pass has 36 meshes to the linear inch. A 36-grain size is approximately $\frac{1}{36}$ in. across.

For grinding tools like plane bits and knives, a medium-fine grain of about 80 is best. For fast cutting where a highly polished surface is not necessary, a grain of about 30 may be used. The speed with which a grinder runs, as well as the grain size, affects the smoothness of grinding. The faster a wheel runs, the smoother it will grind.

By the *grade* of a wheel is meant its softness or hardness, or the ease with which the dulled particles of grit are shed or pulled from the wheel in grinding. A good grinding wheel that is suited to the work being done wears away gradually but slowly, shedding the particles

from the surface as they become dull and exposing sharp particles. If the particles shed too fast, the wheel does not hold its shape well and soon wears out. On the other hand, if the particles do not shed fast enough, the surface of the wheel becomes glazed and rubs instead of cutting, thereby causing excessive heat, which would draw the temper of tools. Grinding wheels vary in grade from very hard to very soft. The grade of a grinding wheel is determined largely by the strength and amount of the binding material used to hold the particles of grit together. Soft-grade wheels are preferred for tool grinding, as there is less danger of drawing temper with such wheels. Manufacturer's or dealer's recommendations are useful in choosing the grade of wheels for particular kinds of grinding.

Testing and mounting a new wheel Sometimes wheels are cracked in shipment or in handling. Before mounting a new wheel, it is a good plan, therefore, to test it for hidden cracks or flaws. This may be done by striking a light blow with a small hammer. If the wheel is sound, it will ring; if there are flaws, it will give a dull thud.

A wheel is commonly fastened to the grinder spindle or shaft by a nut that clamps the wheel between two flanges or disks. Draw the nut up only moderately tight, and be sure there are washers of heavy paper, rubber, or leather between the flanges and the wheel. This is to prevent undue strain on the wheel, which might cause it to crack.

Dressing a grinding wheel A grinding wheel must be dressed occasionally if it is to continue to give good service. It should be

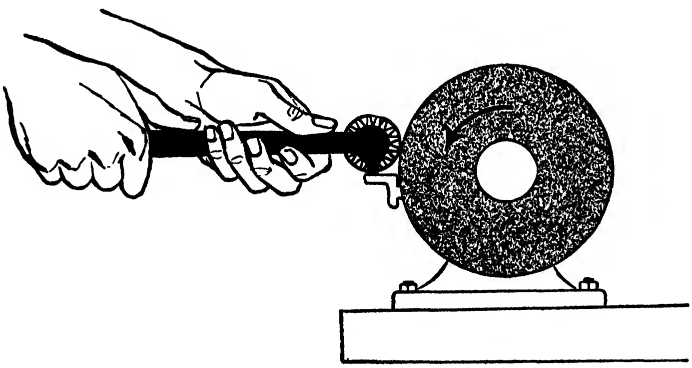


Fig. 7-1. Dressing a grinding wheel. The cutting surface of the wheel is easily and quickly trued, cleaned, and renewed by simply holding the dressing tool firmly against the wheel while it is turning.

dressed if any of the following conditions exist: (1) if the surface is glazed and the dull particles need to be removed; (2) if the pores of the wheel are clogged with dirt, grease, brass, lead, etc.; (3) if the grinding surface is grooved or otherwise out of shape.

To dress a wheel, simply hold the dressing tool firmly against the wheel while it is turning at normal speed (see Fig. 7-1). If a wheel requires dressing too often, it is an indication that it is too soft, too hard, or otherwise unsuited to the kind of grinding being done.

A dressing tool is inexpensive and should be included in the shop equipment along with the grinder.

Observing safety precautions in grinding

Protect eyes and face Always protect the eyes and face while grinding. It is best to wear goggles or a face shield. When goggles are not

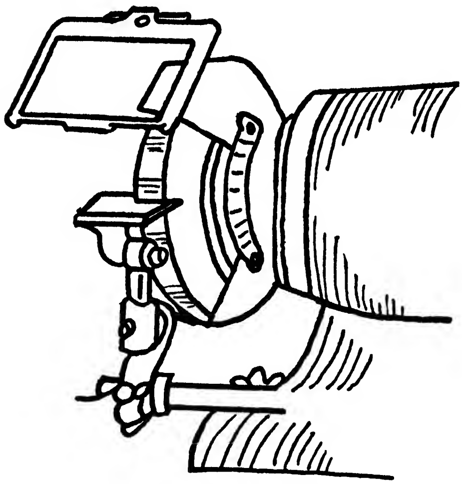


Fig. 7-2. A shatterproof glass shield affords protection against flying particles of grit and metal.

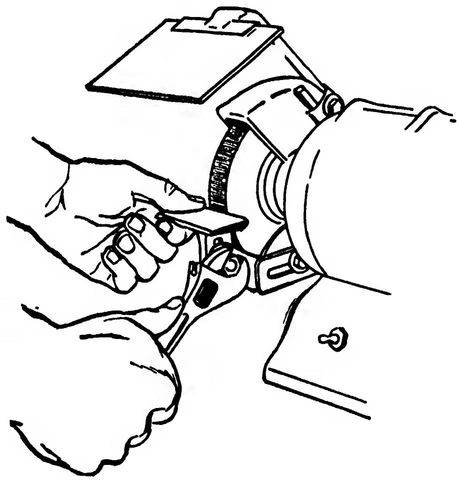


Fig. 7-3. Keep the work rests adjusted so that they just clear the wheels.

worn, glass shields made of shatterproof glass and mounted on the grinder are recommended (see Fig. 7-2). In any event, it is advisable for the operator to stand slightly to one side so that his face will not be in line with the grinding wheel and there will be the least danger from flying sparks, grit, and bits of metal.

Use wheel guards on high-speed power-driven grinders. They keep most of the particles of grit and steel from flying outward toward

the operator, and they also provide a certain measure of protection in case a wheel should break while in use.

Adjust work rests The work rest should be set as close to the wheel as possible without touching (see Fig. 7-3). This is very important. If the rest is too far from the wheel, the piece being ground may catch and wedge between the wheel and the rest and possibly chip or break the wheel or spring the grinder spindle.

Adjust bearings Adjustable bearings should be kept tight and well lubricated. Loose bearings not only allow vibration and cause inferior grinding, but also introduce an element of danger, especially on high-speed grinders.

Selecting and using oilstones An oilstone for sharpening keen-edged tools is indispensable in a good shop. Two kinds of stones are available, natural stones and those made of artificial or electric-furnace abrasives. The artificial abrasive stones are generally preferred, as they are more uniform. A combination stone with one side made of coarse- or medium-grain abrasive and the other made of fine-grain abrasive is recommended. The coarse side is used for faster cutting during the first part of the sharpening, and the fine side for finishing to a keen smooth edge.

Use a light oil, such as kerosene and motor oil mixed in equal parts, on an oilstone to float off the small cuttings of steel and to prevent the surface from becoming clogged with dirt. If a stone is used dry, it soon becomes slick and will not cut fast. A dirty stone may be cleaned by placing it in a pan and heating it in an oven or over a fire, or by washing it in gasoline or kerosene.

Points on selecting and using grinders and oilstones

1. Select a good power-driven grinder for the farm shop. It can well be the most important tool in the shop. A well-built, sturdy grinder with good bearings is worth the additional cost over a cheap grinder.
2. Where a power grinder is not possible, a hand-driven grinder can be used for tool sharpening and light grinding.
3. Select good-quality grinding wheels suited to the kind of grinding to be done. Wheels of aluminum oxide, an abrasive made in the electric furnace, are used for most grinding in the farm shop.
4. Keep the work rests adjusted as close to the wheels as possible without touching.

5. In grinding a tool, hold it against the wheel with a light to medium pressure.
6. Move the work from side to side while grinding to distribute the wear evenly on the wheel and to ensure even grinding.
7. Grind only on the curved face of the grinding wheel, not against the flat sides.
8. If the grinder bearings are adjustable, keep them adjusted.
9. If the grinder bearings need lubrication, do not neglect them.
10. Dress the grinding wheels whenever they become dull (surface glazed) or worn out of shape, or whenever the pores become clogged.
11. Keep safety-glass eye shields in place when grinding, or wear goggles or a face shield. Stand slightly to one side with the face out of line with the wheel to lessen the danger from flying sparks, grit, and bits of metal.
12. Test a new wheel for hidden flaws by striking it lightly with a small hammer. A clear ring indicates a sound wheel; a dull thud, a wheel that is cracked.
13. The nut that holds the wheel in place should be drawn up only moderately tight.
14. Use washers of heavy paper or similar material between the mounting flanges and the wheel.
15. An oilstone for sharpening keen-edged tools is indispensable in the shop. A combination stone, with one side of coarse or medium grit and the other of fine grit, is generally preferred.
16. Always use a light oil, such as kerosene and motor oil mixed in equal parts, on an oilstone.

2. SHARPENING KNIVES

The general method of sharpening keen-edged tools is first to produce a coarse edge by grinding with a grinding wheel, or by whetting on the coarse side of an oilstone, and then to finish by whetting on the fine side of an oilstone. If a very fine edge is needed, the process is carried a step further and the tool is stropped on leather.

Grinding a knife If the blade is nicked or if it is extremely dull, first grind it on a medium or fine grinding wheel. Place the blade flat against the wheel, with the point somewhat higher than the handle.

Raise the back edge of the blade just enough to grind on the cutting edge. Be careful not to raise the back edge too much, as this might cause the wheel to gouge or grind deeply into the cutting edge. Move the blade slowly back and forth at an angle across the wheel (see Fig. 7-4). If the grinding is done on a hand grinder, turn the grinder at a moderate speed and against the cutting edge.

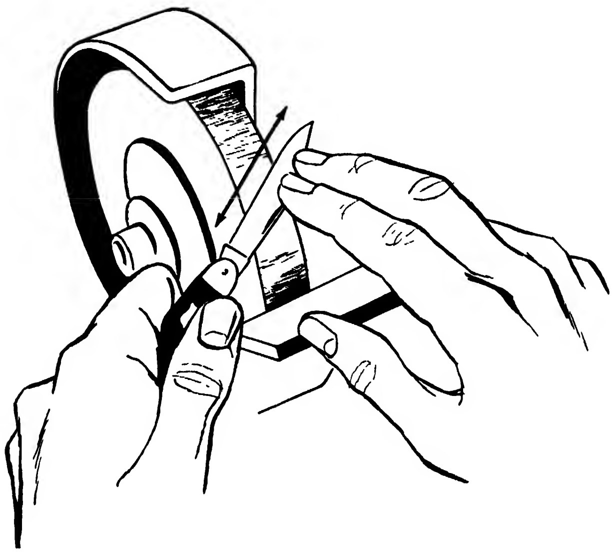


Fig. 7-4. Grinding a knife. Hold the blade at an angle to the wheel, use moderate pressure, and move the knife slowly from side to side.

Be careful not to overheat the blade. Use only moderate pressure, and dip the blade in water frequently. Watch to see that it is being ground to the desired shape.

After grinding a knife, whet it on an oilstone, using the coarse side first unless a very smooth job of grinding was done.

Whetting a knife If a knife is not nicked and is only moderately dull, it may be sharpened on an oilstone without first being ground. Although it may be sharpened entirely on the fine side of the stone, it is generally faster first to whet on the coarse and then to finish on the fine side.

To keep a stone from sliding around when in use, it may be mounted on a small board about 1 by 4 by 10 in. long, with small strips tacked to the board to hold the stone in place.

Stroke 1 To whet a knife, put a few drops of light oil, such as motor oil mixed with kerosene, on the stone and place the blade flat

as shown in position 1, Fig. 7-6. Raise the back of the blade just enough to make the cutting edge touch the stone. Then draw the knife across the stone diagonally into position 2. Be sure to keep the heel of the blade down against the stone at the beginning of the stroke, and use moderate to heavy pressure.

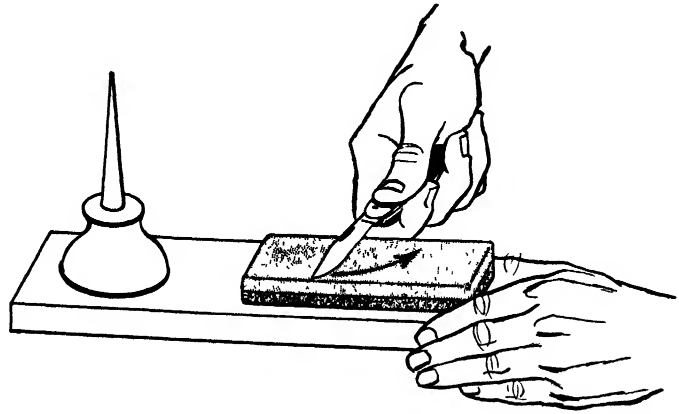


Fig. 7-5. After grinding, a knife is whetted on an oilstone. If the blade is not nicked and is only moderately dull, it may be sharpened altogether on an oilstone.

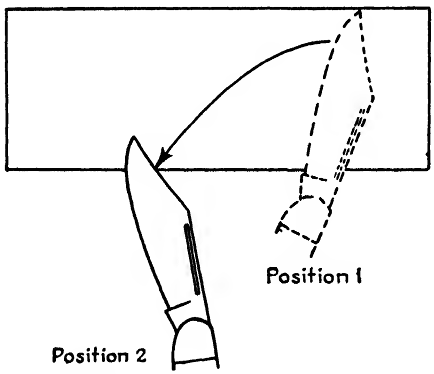


Fig. 7-6. Stroke 1 in whetting a knife. Raise the back of the blade slightly and draw it diagonally across the stone.

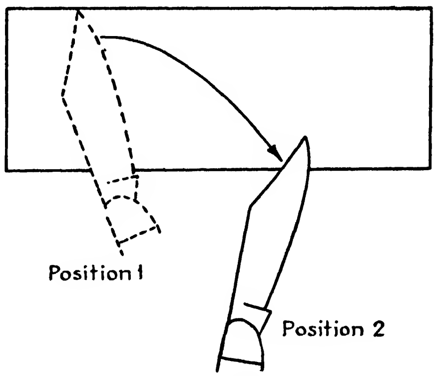


Fig. 7-7. Stroke 2 in whetting a knife. With a little practice, strokes 1 and 2 will blend together into a continuous motion.

Stroke 2 Next, turn the blade over into position 1, Fig. 7-7. Tilt the blade by raising the back edge slightly, and draw it diagonally over the stone into position 2. Repeat these two strokes several times. With practice, they will blend into one continuous motion.

If the whetting is being done on the coarse side of the oilstone, continue until a fine burr or wire edge has been produced. A wire edge is

a thin rough edge that can be felt with the thumb or finger (see Fig. 7-8), or seen in a good light (see Fig. 7-12). Also, a wire edge will catch on a cloth while a smooth edge will not.

After a wire edge is produced, turn the stone over and whet it on the fine side, using light pressure and the same diagonal drawing strokes. If the whetting is done properly, the wire edge will quickly disappear and the knife will be really sharp.

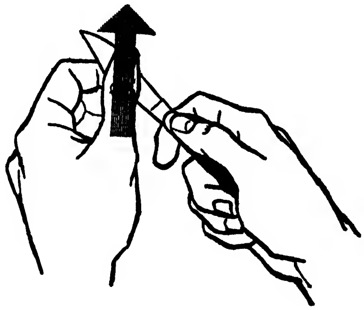


Fig. 7-8. Feeling to find out if the knife has a wire edge. Note the motion of the thumb.

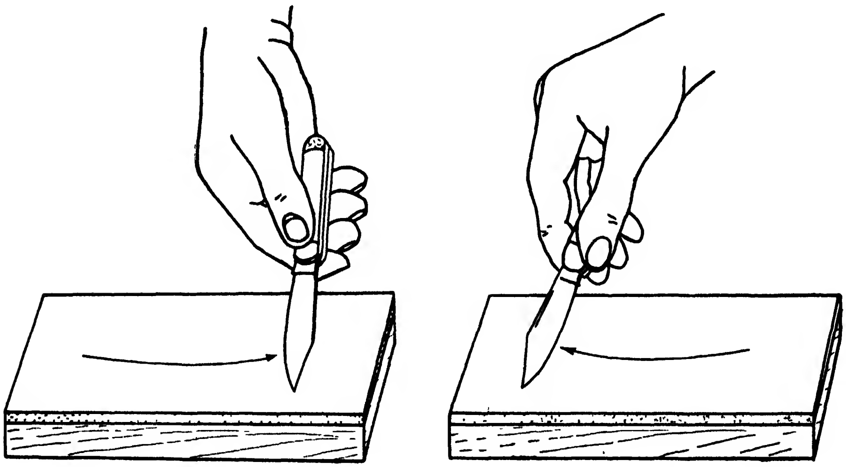


Fig. 7-9. To produce a fine, keen edge strop the knife on leather after whetting on the oilstone. After stroke 1, roll the knife over on the back of the blade into position for stroke 2. With practice, strokes 1 and 2 will blend together into a continuous motion.

Stropping a knife To produce an exceptionally fine keen edge, strop the knife on a piece of smooth leather after it has been whetted on the fine side of the oilstone. Be sure to use pulling strokes with the cutting edge trailing—not leading (see Fig. 7-9). If a strop is not available, the knife may be stropped on a piece of smooth wood, on a shoe sole, or even on the palm of the hand. A piece of smooth leather

glued to a block of wood about 2 in. wide by 6 in. long makes a good strop.

Testing a knife for sharpness Probably the best way to tell whether or not a knife is sharp—the way used by most good mechanics—is to

Fig. 7-10. An excellent way to test a knife for sharpness. Draw the ball of the thumb lightly along the edge. Do not press. A sharp edge will "take hold" or pull on the tough cuticle. A dull tool feels smooth and will not "take hold."

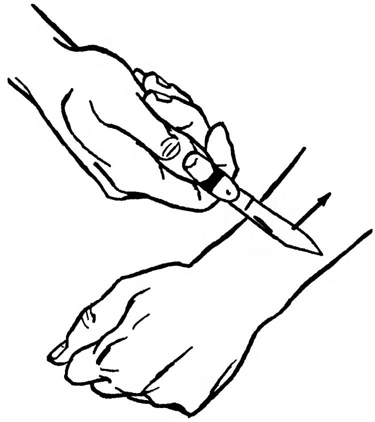


Fig. 7-11. A sharp tool will easily shave.

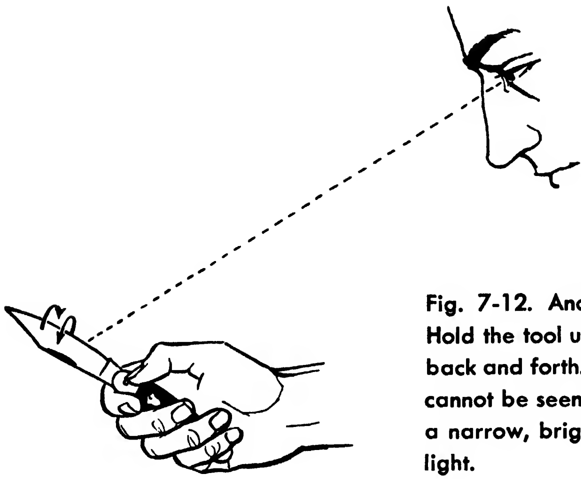


Fig. 7-12. Another test for sharpness. Hold the tool up to the light and move it back and forth. The edge of a sharp tool cannot be seen. A dull edge appears as a narrow, bright, shiny line that reflects light.

feel it with the thumb. Hold the blade, cutting edge up, in the open hand, and with *very light pressure* move the thumb lengthwise along the edge (see Fig. 7-10). Do not press against the edge. If the knife "takes hold" or pulls on the calloused skin of the thumb, it is sharp; if it does not take hold, or feels slick and smooth, it is dull.

Another test is the shaving test (see Fig. 7-11). It is not too much to expect a knife to shave. With a little practice, one should be able to put a shaving edge on a knife.

Still another way to test the knife for sharpness is to hold it up to the light and rock the blade back and forth (see Fig. 7-12). If the knife is dull, the edge of the blade can be seen. It will reflect the light and appear as a narrow shiny surface. If the knife is sharp, the edge cannot be seen.

Sharpening butcher knives A butcher knife is sharpened in the manner described in the preceding paragraphs. It is ground if necessary and then whetted on an oilstone. The edge of a butcher knife can

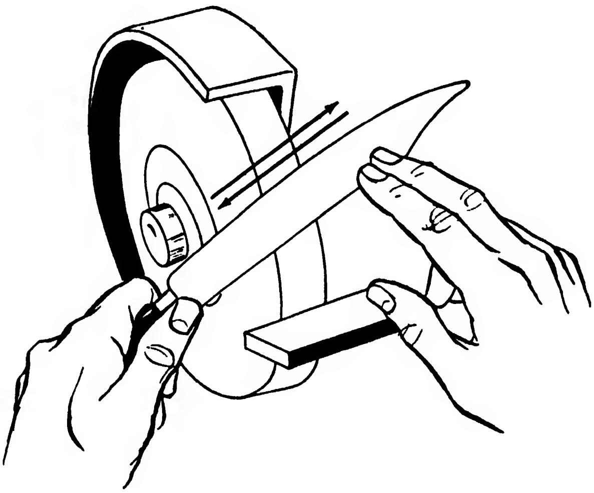


Fig. 7-13. A butcher knife may be sharpened in the same way as a pocket knife. Grind it first if necessary and then whet it on an oilstone.

be kept in good condition by using a sharpening steel on it occasionally. The steel does not really sharpen the knife, but simply removes bits of fat and tissue and straightens the microscopic teeth that form the edge.

To use the sharpening steel, hold the steel in the left hand with the point up (see Fig. 7-14). Tilt the blade slightly so that the cutting edge is in contact with the steel, and beginning at the heel of the blade, draw it down quickly with a diagonal sweeping stroke, cutting edge foremost. Use only light pressure. In a similar manner, stroke the other side of the blade on the other side of the steel, and continue, stroking first one side of the blade and then the other.

Sharpening drawknives A drawknife is sharpened in the same manner as other keen-edged knives, except that, in whetting, the stone may be rubbed over the edge, instead of moving the tool back and forth over the stone (see Fig. 7-15).

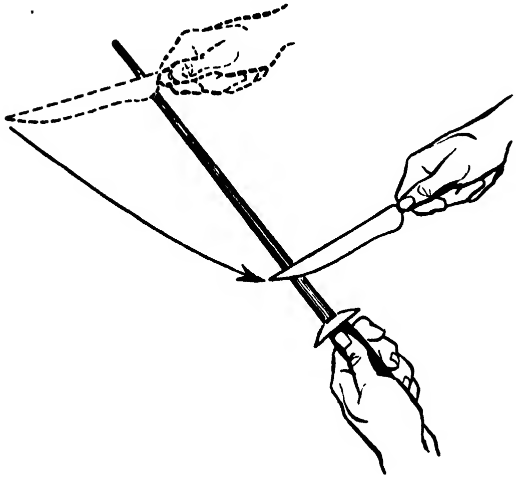


Fig. 7-14. Using the sharpening steel occasionally will help keep the butcher knife in good condition.

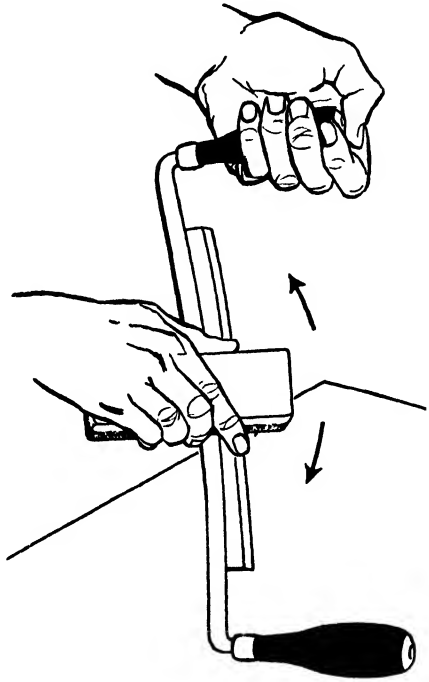


Fig. 7-15. A drawknife is sharpened in the same manner as other keen-edged tools, except that, in whetting, the stone may be rubbed over the edge of the tool instead of moving the tool back and forth over the stone.

3. SHARPENING AXES AND HATCHETS

To sharpen an ax or a hatchet, first grind it on a medium or fine grinding wheel if the edge is blunt or if it is nicked. After grinding, whet it with an oilstone to produce a keen smooth edge (see Fig. 7-16). The stone may be rubbed on the tool, or if more convenient, the stone may be placed on a bench and the tool rubbed on the stone. If the tool is only slightly dull, it may be sharpened altogether with an oilstone. In grinding an ax for chopping, the blade should be made somewhat thinner than an ax for splitting. Be careful not to overheat the tool when grinding.

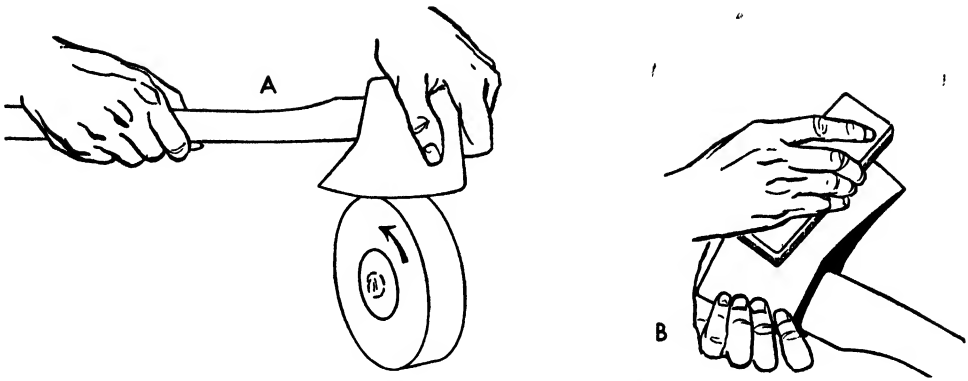


Fig. 7-16. Sharpening an ax. After grinding (*A*), a smooth, keen edge may be produced by whetting with an oilstone (*B*).

4. SHARPENING PLANE BITS AND WOOD CHISELS

When a plane bit or wood chisel becomes dull, decide first whether it is necessary to grind it. If a tool is properly used and cared for, it can be resharpened many times on the oilstone before it will need regrinding. The tool should be ground if the edge is unusually dull or nicked, or if a slight bevel has been formed on the flat side by careless whetting. The tool should be ground, also, if it does not have the desired angle of bevel, or if the cutting edge is not square with the sides.

Checking angle and shape of cutting edge For general work, grind plane bits and wood chisels at an angle of about 25 to 30 deg (see Fig. 7-17). For softwoods, the angle may be somewhat less, and for hardwoods, somewhat more. The smaller the angle, the more easily the tool will cut, but the sooner it will become dull.

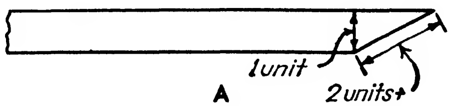
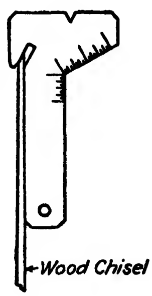


Fig. 7-17. *A*, the length of bevel on a plane bit or wood chisel should be a little more than twice the thickness of blade for general-purpose work. *B*, checking the angle of bevel with a homemade gage. (See also Fig. 7-42.)



The bevel should be ground straight or slightly concave—not rounded or convex (see Fig. 7-18). For general-purpose planes, it is desirable to grind the corners of the blade slightly rounded as shown in Fig. 7-19. This is to feather the sides of the shaving and avoid scratches or grooves in the surface being planed.

Some mechanics prefer to straighten the edge of a plane bit or wood chisel by rubbing it on the edge of an oilstone before grinding (see Fig. 7-20).

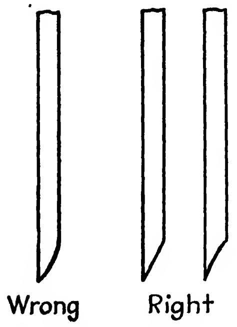


Fig. 7-18. An edge tool like a plane bit or wood chisel should be ground with a straight or a concave bevel—not with a convex bevel.

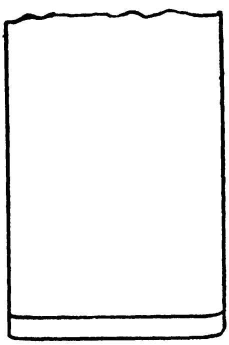


Fig. 7-19. A plane for general-purpose work should be ground with the corners slightly rounded.

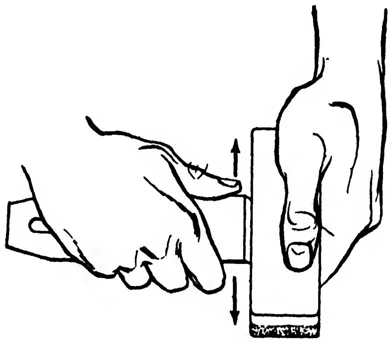


Fig. 7-20. The edge of a plane bit or wood chisel may be straightened or squared on the edge of an oilstone.

Grinding plane bits and wood chisels In grinding a plane bit or wood chisel, the following points are important:

1. Hold the tool against the wheel in a manner that will produce a smooth, even bevel of the desired angle.
2. Adjust the work rest, if possible, so that the tool, when held firmly against the rest, will come in contact with the wheel at the desired angle (see Fig. 7-22).
3. Grasp the tool so that the first finger will come against the work rest; this will enable you to replace the tool in proper position after it has been removed for inspection or dipping into water.
4. Turn the wheel toward the cutting edge—not away from it.
5. Turn at a moderately fast, steady speed. Do not turn so fast that the gears whine or the grinder vibrates.

6. Hold the tool against the wheel with a medium, yet firm, pressure.
7. Move the tool from side to side across the face of the wheel.
8. Dip the tool into water frequently to prevent overheating.
9. Inspect the work frequently to see that the tool is being ground to the proper shape and angle of bevel.

A quick, easy way to check the angle of bevel is to use a simple gage cut from sheet metal (see Fig. 7-17*B*). (A combination gage for

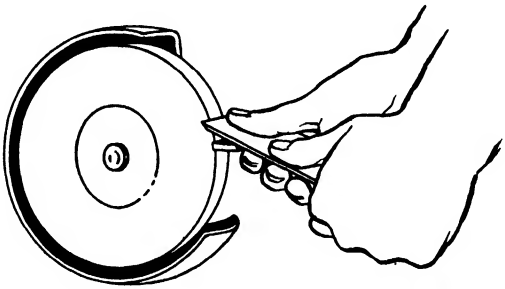


Fig. 7-21. Grinding a plane bit on a power grinder. Note that the first finger of the right hand comes against the front edge of the tool rest. This enables the tool to be replaced against the wheel at just the right angle.

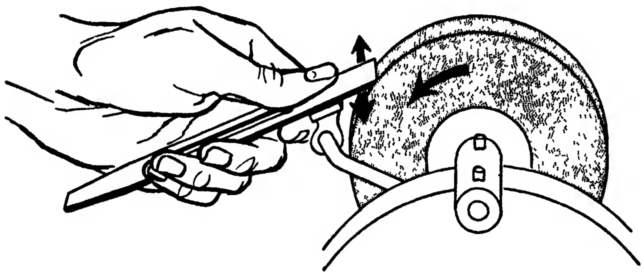


Fig. 7-22. A good method of holding the tool when grinding with a hand grinder. Adjust the tool rest to give the desired angle of bevel and hold the tool firmly against the rest. Move the tool back and forth sideways across the face of the wheel.

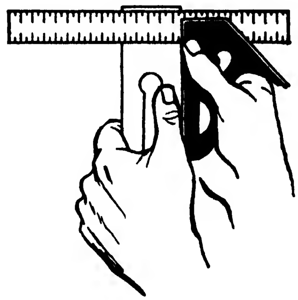


Fig. 7-23. Checking an edge tool for squareness of grinding. Place the square on top of the blade but be careful not to touch the sharp edge against the square.

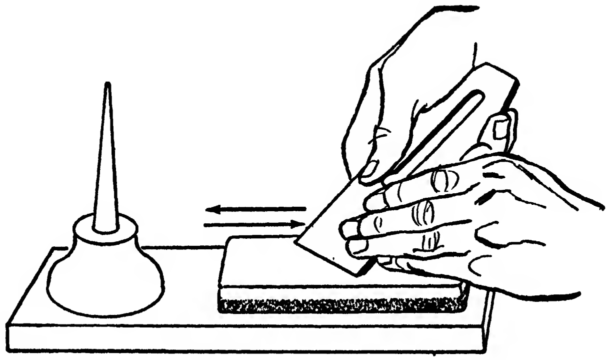
checking the grinding of plane bits and wood chisels, twist drills, and cold chisels is illustrated in Fig. 7-42.) With a little practice, the angle of bevel can be checked by eye, by remembering that the length of bevel should be a little more than twice the thickness of the blade (see Fig. 7-17*A*). A rule can be used, of course, for measuring the length of the bevel and the thickness of the blade.

To check to see that the cutting edge is square with the edges of the tool, use a square (see Fig. 7-23). Place the square on top of the blade,

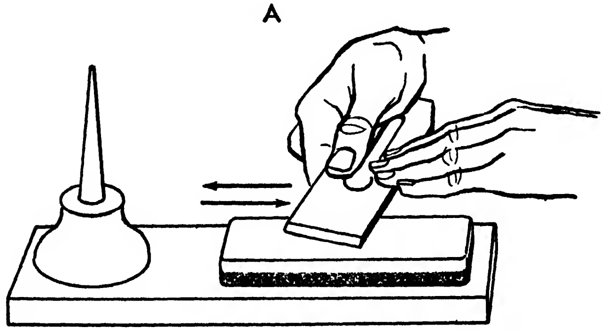
allowing the cutting end to project slightly beyond the square. Be careful not to touch the cutting edge against the square.

Continue grinding until the dull edge is removed, all nicks are removed, the edge is straight and square, and the bevel is of the desired angle. Remove the burr, or wire edge, which is left from grinding, by whetting on an oilstone.

Whetting a plane bit or wood chisel If the tool has a good bevel on it and is not nicked, but is simply dull, it can be quickly sharpened by whetting it on an oilstone without first grinding it. Place a few drops of



A



B

Fig. 7-24. If a plane bit or wood chisel is not nicked and is only moderately dull, it may be sharpened on the oilstone without first grinding. Whet as at *A*, using the coarse side of the stone. Then whet alternately as at *A* and *B*, using the fine side. When whetting in position *B*, keep the tool perfectly flat against the stone. Note that the cutting edge makes an oblique angle with the edge of the stone in both positions.

oil on the coarse side of the stone, and whet the bevel of the tool until a slight burr, or wire edge, is formed.

In whetting, place the tool on the stone with the cutting edge making an oblique angle with the edge of the stone (see Fig. 7-24*A*). Keep the

bevel of the tool flat on the stone, *or with the heel raised only very slightly.* Push the tool forward and backward, bearing down hard on the forward stroke but relieving the pressure on the backstroke. Be particularly careful to move the hands parallel to the surface of the stone and not to allow a dipping or scooping motion, as this would round the end of the tool as well as hollow out the stone. Use full-length strokes.

After a slight wire edge has been produced by wheting on the coarse side of the stone, or by grinding on the grinding wheel, remove the wire edge by whetting on the fine side of the stone. Place the tool *perfectly flat* on the stone, with the cutting edge making an oblique angle with the edge of the stone, and push it forward (see Fig. 7-24*B*).

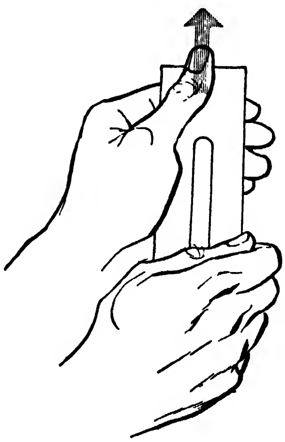


Fig. 7-25. Feeling to find out if there is a wire edge on a plane bit. Wire edges are removed by light whetting on an oilstone.

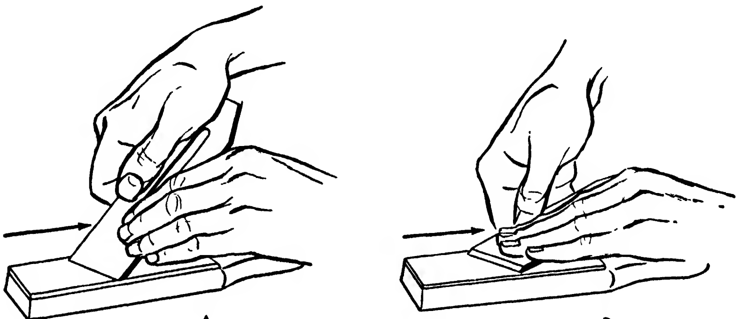
A few strokes will either remove the wire edge or turn it from the flat side of the tool to the beveled side. If the wire edge turns, then turn the tool over to the position shown in *A,* Fig. 7-24, and whet lightly on the beveled edge. Then reverse the tool, and whet again on the flat side. In this operation, two points are very important: (1) Keep the tool perfectly flat against the stone when whetting on the flat side. (2) Use very light pressure when whetting the beveled side.

If the whetting is properly done, the wire edge will quickly become smaller and smaller and, after a few reversals, practically disappear. The tool will then be sharp. Some time may be saved in removing the wire edge by drawing it through a piece of wood.

If the tool is not held perfectly flat when whetting the flat side, a small bevel may be produced on the flat side, and it will then be impossible to put the edge in good condition without regrinding it. If too much pressure is used while whetting the beveled side, the wire edge may be increased instead of decreased.

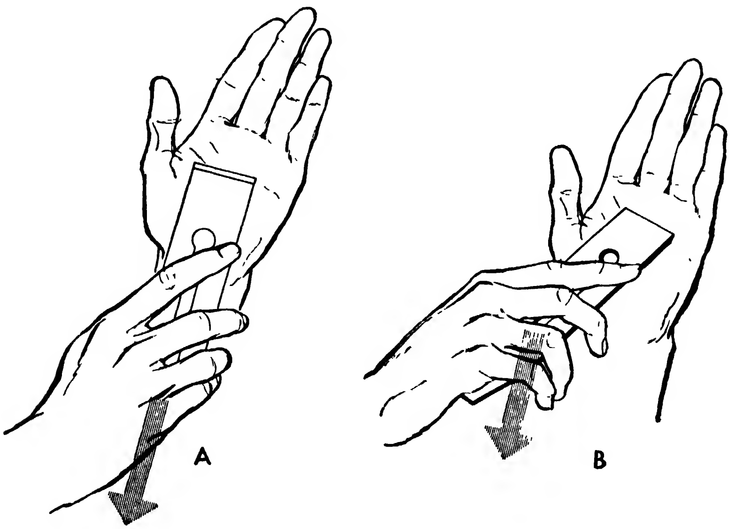
In alternately whetting the flat and the beveled side, make sure that the wire edge is actually turned back and forth. For example, if the tool is being whetted on the flat side, be sure the wire edge is actually turned from the flat to the beveled side before reversing the tool for whetting on the beveled side. A wire edge is easily detected by feeling with the thumb or finger. Place the thumb against the side of the tool, and move it lengthwise of the tool out over the cutting edge (see Fig. 7-25).

Stropping a plane bit or wood chisel To produce an exceptionally fine, keen edge on a tool, strop it on a piece of smooth leather after



A B

Fig. 7-26. A very keen edge may be produced on a tool by finishing on a leather strop. Using draw strokes, strop first on the beveled side and then on the flat side.



A B

Fig. 7-27. If a leather strop is not available, an edge tool may be stropped on the palm of the hand.

it has been whetted on the fine side of the oilstone (see Fig. 7-26). A few drawing or pulling strokes with the cutting edge trailing, not leading, first on the beveled side and then on the other, are all that is required. If a piece of leather is not available, the tool may be stropped on a piece of smooth wood, or even on the palm of the hand (see Fig. 7-27).

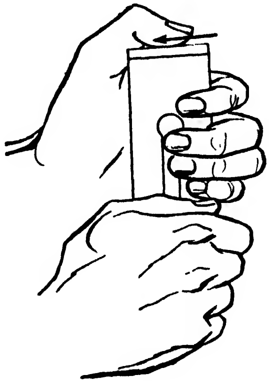


Fig. 7-28. Testing a plane bit for sharpness. Draw the ball of the thumb lightly along the edge, but do not press against it. A sharp tool will "take hold" and pull on the tough cuticle, while a dull tool feels smooth and will not "take hold."

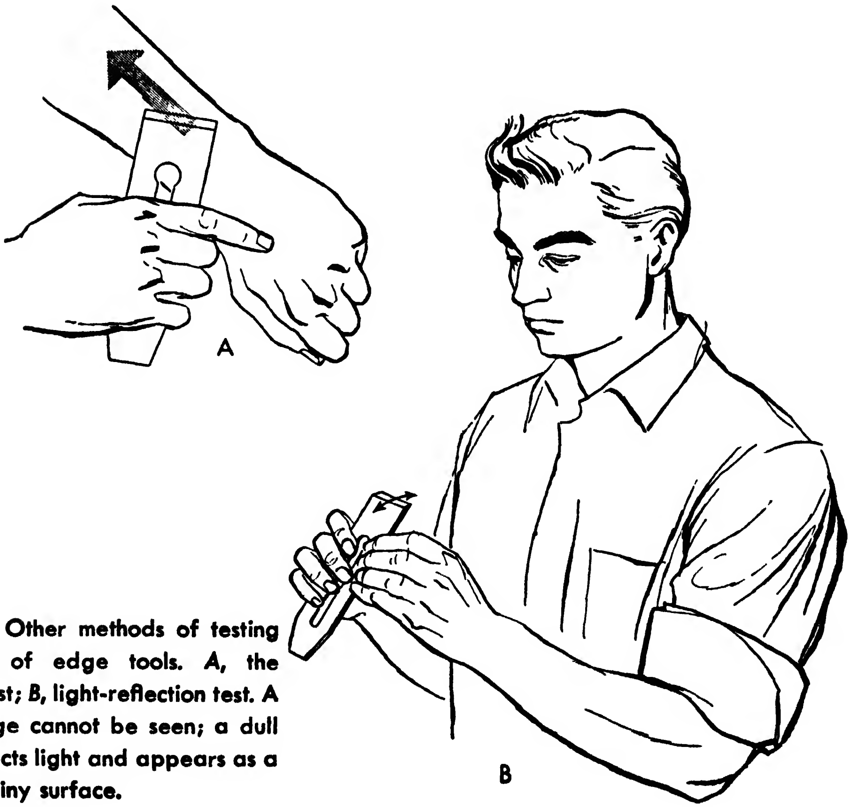


Fig. 7-29. Other methods of testing sharpness of edge tools. *A*, the shaving test; *B*, light-reflection test. A sharp edge cannot be seen; a dull edge reflects light and appears as a narrow, shiny surface.

5. SHARPENING WOOD SCRAPERS

Filing and whetting the edge The first step in sharpening a hand wood scraper is to drawfile the edges square and straight, rounding the corners slightly (see Fig. 7-30). Use a rather fine file, such as a smooth mill file.

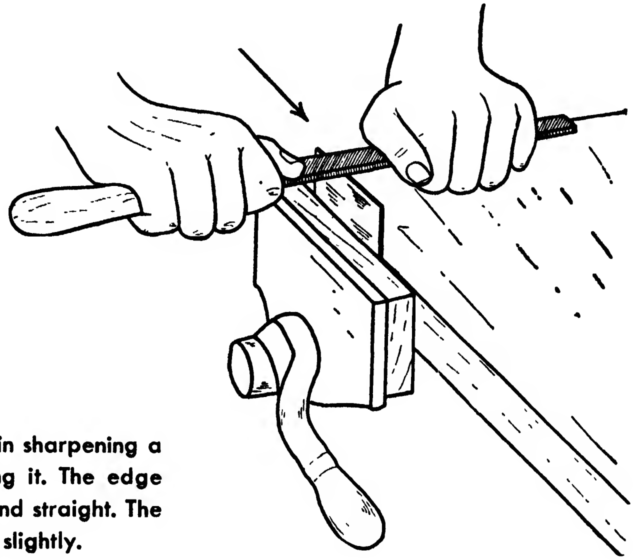


Fig. 7-30. The first step in sharpening a very dull scraper is filing it. The edge should be kept square and straight. The corners may be rounded slightly.

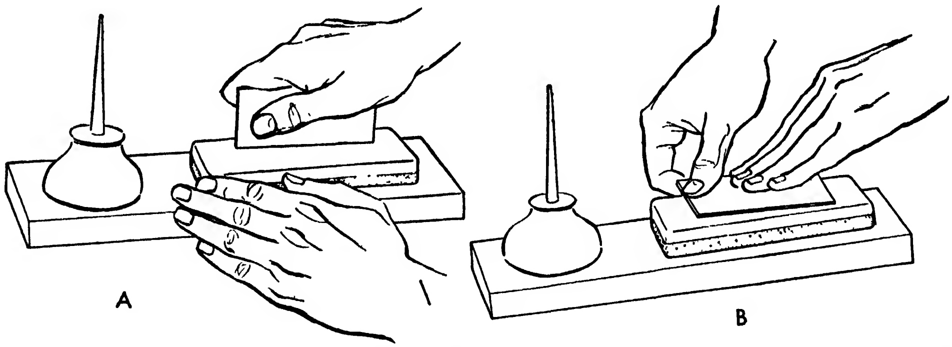


Fig. 7-31. After filing, whet the scraper alternately on edge and on the flat side. Use the fine side of the oilstone.

Next, whet the scraper on an oilstone, first on the edge and then on the flat side to make the arrises smooth and sharp (see Fig. 7-31). (An arris is a sharp edge formed by the meeting of two surfaces.)

Forming the scraping burr (burnishing) After filing and whetting, form a small scraping burr by stroking the scraper with a burnisher or other piece of smooth hard round steel, like a nail set.

Place the burnisher flat against the side of the scraper and draw it along over the edge (see Fig. 7-32). Use moderate pressure, and repeat the stroke two or three times. Turn the scraper over, and burnish the other side in the same manner. A drop or two of oil on the burnisher makes it work better.

After burnishing the flat sides of the scraper, burnish the edge. Place the scraper in a vise or hold it firmly in an upright position on the

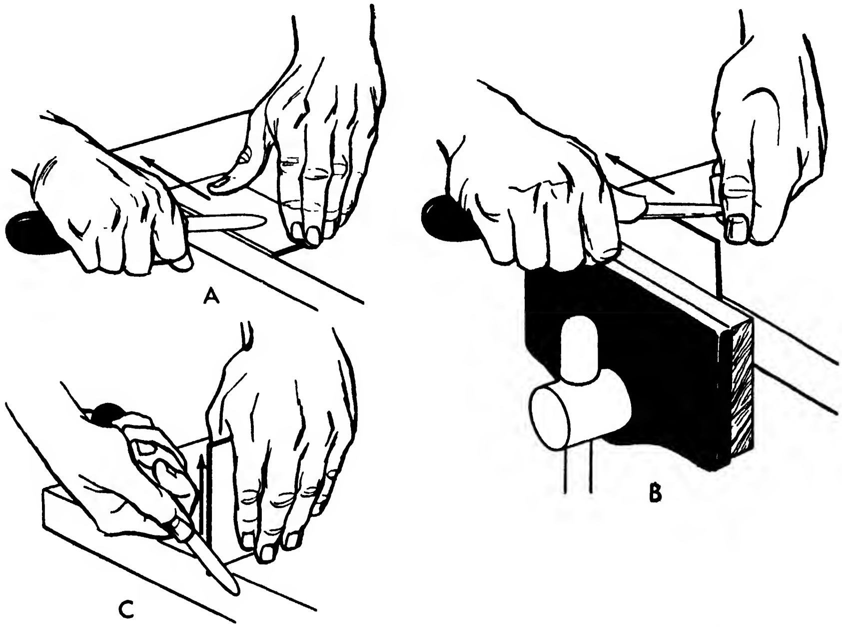


Fig. 7-32. Forming the scraping burr on a scraper. Draw the burnisher over the edge three or four times, use moderate pressure, and keep the burnisher flat against the scraper as at A. Then turn the burr with three or four strokes as at *B* or C. (See also Fig. 7-33.) A little oil on the burnisher makes it work better.

bench. Hold the burnisher square with the edge and draw it along with the handle end slightly ahead (see Fig. 7-32*B* or *C*). Use only moderate pressure. Heavy pressure is not required. Be sure to keep the burnisher square with the scraper on the first stroke. Repeat the stroke two or three times, each time tilting the burnisher a little, until the last stroke is made at an angle of about 85 deg instead of 90 deg. Then turn the scraper around and burnish from the other side in the same manner. The scraping burrs are then as shown in *B,* Figs. 7-33 and 7-34.

The edge of a scraper may be renewed several times with the burnisher before it will need refiling and whetting.

Fig. 7-33. In turning the burrs on a scraper, hold the burnisher at 90 deg to the scraper on the first stroke, and then gradually tilt it on succeeding strokes until it finally makes an angle of about 85 deg on the last stroke.

Sharpening a beveled-edge scraper The blade of a cabinet scraper is usually sharpened to a beveled edge instead of a square edge. Some mechanics prefer hand wood scrapers sharpened with beveled edges also. When a scraper is sharpened to a beveled edge, the angle of bevel is usually about 45 deg, or about double that of a plane bit.

The first step in sharpening a beveled scraper is to remove the old burr with a file and then to file the edge to the desired bevel. Then whet it on an oilstone, first on the beveled edge and then on the flat side, to remove the wire edge left by filing.

Fig. 7-34. *A*, shape of scraping burr after burnisher has been used on flat sides of scraper. *B*, shape of burr after burnisher has been used on edge of scraper.

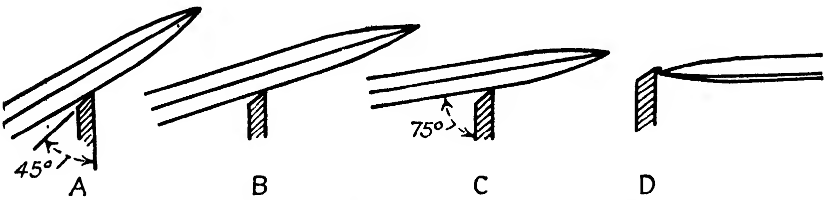


Fig. 7-35. Steps in turning a burr on a beveled-edge scraper. If the burr is turned too much, it may be raised somewhat, as at *D*.

Next, burnish the edge in much the same manner as for a square-edged scraper. Burnish first on the flat side. Then burnish the beveled edge, with the burnisher flat against the bevel on the first stroke, and at a little greater angle on each succeeding stroke, until finally it makes an angle of about 75 deg with the side of the scraper on the last stroke (see Fig. 7-35). In case the burr is turned too much, it may be raised somewhat by drawing the point of the burnisher along under the burr as shown in Fig. 7-35*D*.

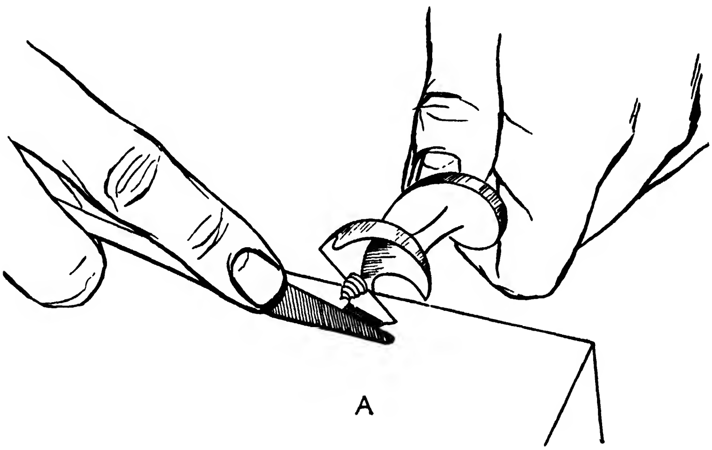
6. SHARPENING AUGER BITS

A small file, known as an *auger-bit file,* is best for sharpening an auger bit. A small triangular or three-cornered file, or a small flat file, may be used, if the workman is careful.

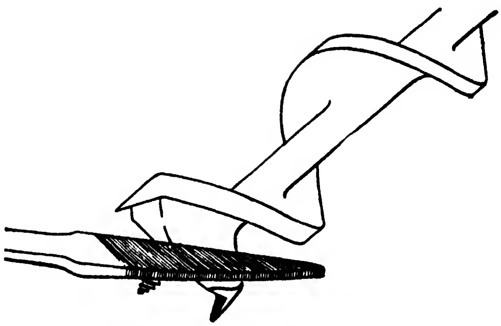
The following points are important in sharpening an auger bit:

1. File on the inside of the spurs or scoring nibs.
2. File on the top side of the cutting lips (the side next to the shank).
3. Retain the original bevel or suction on the cutting lips, and remove about the same amount of material from each one.

To file the spurs or scoring nibs, hold the bit firmly against the edge of a bench or other support (see Fig. 7-36). File on the inside of the nibs. If they are filed on the outside, they will cut a circle that is too



A



B

Fig. 7-36. Two points are important in sharpening auger bits: A, file the spurs on the inside only. *B,* file the cutting lips on the top side (next to the shank).

small and the bit will not feed into the wood. In case the nibs have been bent outward, or burrs have been formed on the outside, they may be filed lightly on the outside, care being taken not to undercut or bevel the nibs on the outside.

To file the cutting lips, rest the bit firmly against the bench top as shown in Fig. 7-36*B*. Be careful to retain the original angle of bevel or suction and to file both lips about the same amount.

7. SHARPENING TWIST DRILLS

Sharpening of twist drills is one of the most important jobs in the farm shop. Drilling equipment enables many repair jobs to be done that otherwise would be impossible. Yet drilling equipment is practically worthless without sharp drill bits, and if drill bits are used much, they will require frequent resharpening. Most drilling difficulties and most drill breakage can be traced to faulty sharpening.

Checking proper shape of drill point Before attempting to grind a twist drill, one should have a clear picture in mind of the shape of a properly sharpened drill. There are two main requirements:

1. The cutting lips must have clearance or be ground off behind the cutting edge to allow the drill to bite into the metal. The proper clearance is about 12 deg.
2. The cutting edges should be exactly the same length and make the same angle with the central axis of the drill, the proper angle being about 59 deg, or practically two-thirds of a right angle. (The axis is an imaginary center line running lengthwise of the drill from one end to the other.)

If the cutting lips do not have clearance, the drill cannot bite into the metal, and if there is too much clearance, the drill may take too deep a bite or gouge.

If both cutting edges are the same length and make the same angle with the central axis, the point of the drill will be centered. If the point is not centered, the drill will make an oversized hole, and one lip will do more than half of the cutting.

If the cutting lips are not ground at the proper angle of 59 deg with the axis, the cutting edges will be slightly curved instead of straight, and the drill will be too pointed or too blunt.

Judging lip clearance To judge lip clearance, hold the drill up about level and look straight at the end of it (see Fig. 7-37). Rotate the drill until the cutting edges are about horizontal or level (see Fig. 7-38). The short line across the end should then be about halfway

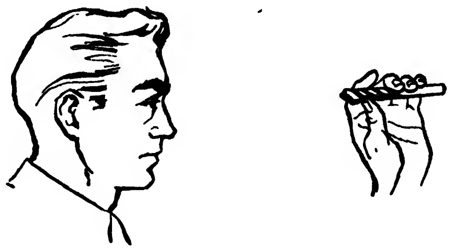


Fig. 7-37. To judge the lip clearance of a drill, hold it up about level and look straight at the end of it. (See also Fig. 7-38.)

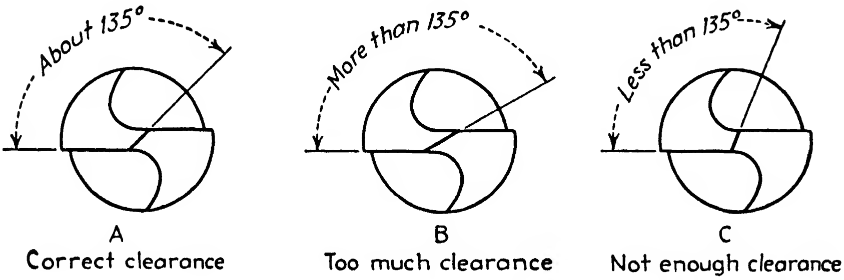


Fig. 7-38. Judging lip clearance. With the cutting edges horizontal, the short line across the end of the drill should be about halfway between vertical and horizontal, as at A. If it is much more nearly horizontal than vertical, as at B, the lips have too much clearance. If the short line is nearly vertical, as at C, the lips have insufficient clearance.

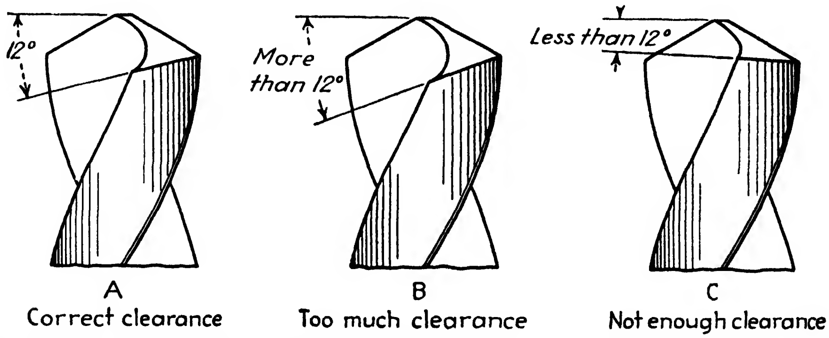


Fig. 7-39. Judging the lip clearance at the outer edge or periphery of the drill.

between the vertical and horizontal (see Fig. 7-38*A*). If it is much nearer horizontal than vertical (Fig. 7-38*B*), the lips have too much clearance. If the short line is much nearer vertical than horizontal (Fig. 7-38*C*), the lips do not have enough clearance.

The amount of clearance, particularly at the outer edge or periphery of the drill may be judged by simply looking at the outer edge of the cutting end (see Fig. 7-39), or by standing the drill vertically, point down, against the bench top beside a rule (see Fig. 7-40) and turning the drill slowly. The heel of the cutting lip should register slightly higher on the rule than the front edge. Sometimes drills are ground

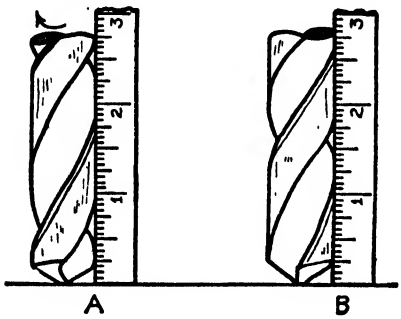


Fig. 7-40. Lip clearance at the outer edge may also be judged by standing a drill beside a rule and rotating it. The heel of the cutting end (*B*) should register higher on the rule than the front cutting edge (*A*).

with proper lip clearance at the outer edge or periphery, yet with improper clearance at the center. Therefore, clearance should not be judged by looking at the outside edge alone.

Checking length and angle of cutting edges The length of the cutting edges and the angle between the cutting edges and the central axis of the drill can best be checked by a gage (see Fig. 7-41). Such a gage can be made easily from sheet metal (see Fig. 7-42). With some practice, however, one can become reasonably proficient at checking the lengths and angle of the cutting edges by eye. Lengths of cutting edges can be measured, of course, with a rule.

Placing the drill in position for grinding The work rest on the the grinder should be at about the same level as the wheel shaft. Adjust it if necessary; then place the drill on the work rest with

1. The drill about level (both ends about the same height).
2. The axis of the drill making an angle of about 59 deg with the cutting surface of the wheel (see Fig. 7-43). (It is a good plan to file a line on the work rest at the 59-deg angle.)
3. One cutting edge horizontal and against the grinding wheel. (Rotate the drill if necessary, but keep the drill about level.)

The drill may be held in proper position against the wheel by placing the first finger of the left hand on the work rest, and resting the end of the drill on the finger (see Fig. 7-44). Be careful not to let the finger come in contact with the wheel. If the work rest is very narrow, the end of the drill may be rested on the work rest directly, as shown in Fig. 7-45.

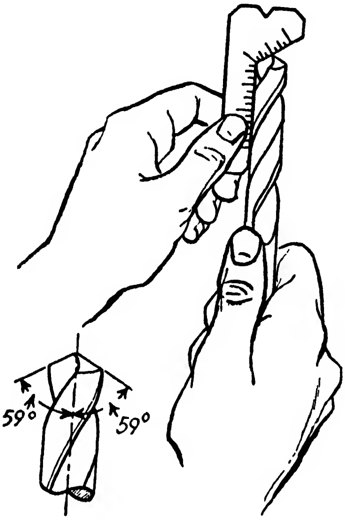


Fig. 7-41. Checking the cutting lips for length and for angle with the central axis of the drill. Both lips should be the same length and should make an angle of about 59 deg with the central axis. (The notch in the end of the gage is for checking the angle of bevels on a cold chisel.)

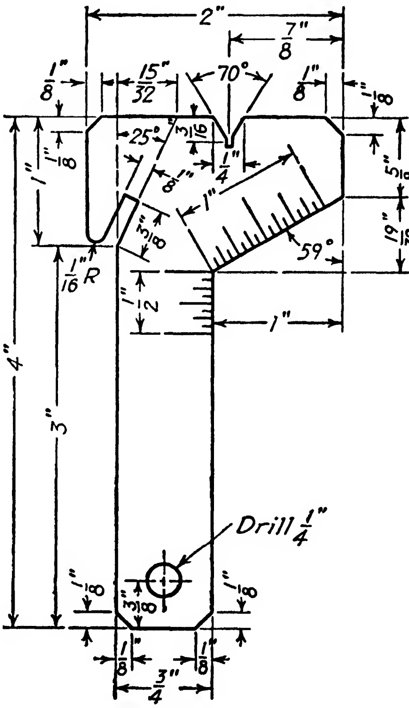


Fig. 7-42. A plan for a homemade grinding gage for checking twist drills, cold chisels, and plane bits and wood chisels.

If a power grinder is not available, drills may be ground on a hand-operated grinder. In this case, the drill must be held in the left hand while the grinder is turned with the right (see Fig. 7-45).

Grinding the drill With the drill in proper position and the wheel turning at normal speed, push the cutting end *slowly*, yet firmly, against the wheel, and then slowly elevate the point by gradually lowering the other end. Keep the point pushed against the wheel. Make slow, deliberate strokes—not fast, quick thrusts. Do not attempt to roll or

rotate the drill while it is being ground—at least, not until you have become rather expert—but simply keep the point pushed against the wheel while the other end is slowly lowered.

When one lip is ground, rotate the drill half a round and grind the other lip in identically the same manner. Dip the drill in water fre-

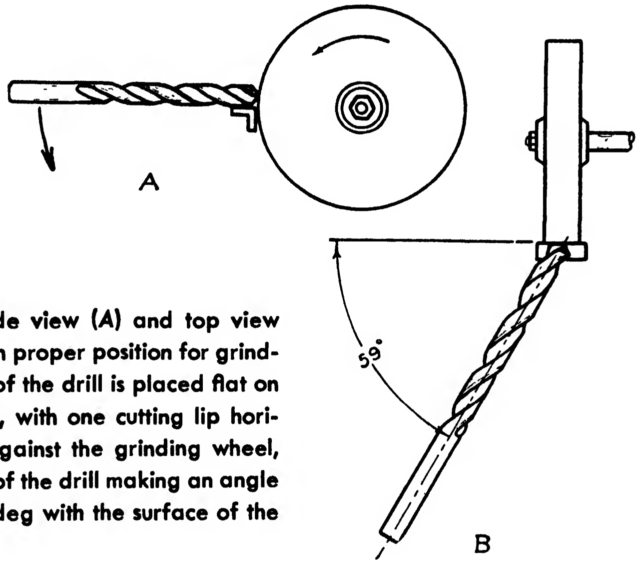


Fig. 7-43. Side view (A) and top view (B) of a drill in proper position for grinding. The end of the drill is placed flat on the work rest, with one cutting lip horizontal and against the grinding wheel, with the axis of the drill making an angle of about 59 deg with the surface of the wheel.

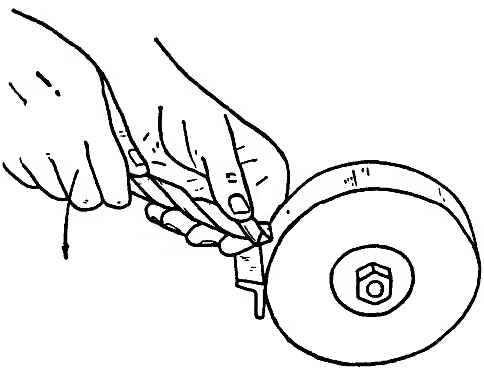


Fig. 7-44. The end of the drill may be supported by the first finger of the left hand, which is placed on top of the work rest. Be careful not to let the finger touch the grinding wheel.

quently to prevent overheating and drawing the temper. Inspect the work every few grinding strokes, to make sure the drill is being ground properly. Check both for clearance and for length and angle of cutting edges.

If more clearance is desired, grind more on the last part of the stroke

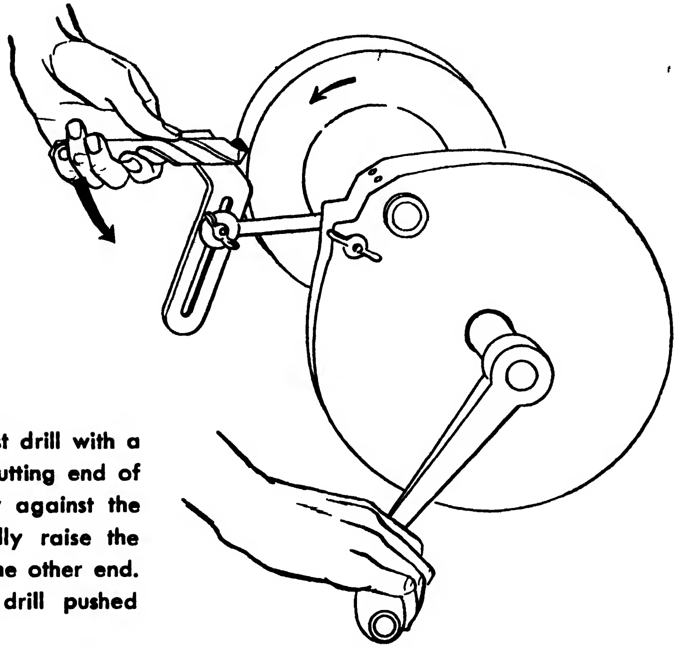


Fig. 7-45. Grinding a twist drill with a hand grinder. Force the cutting end of the drill slowly but firmly against the revolving wheel. Gradually raise the cutting end by lowering the other end. Keep the point of the drill pushed against the wheel.

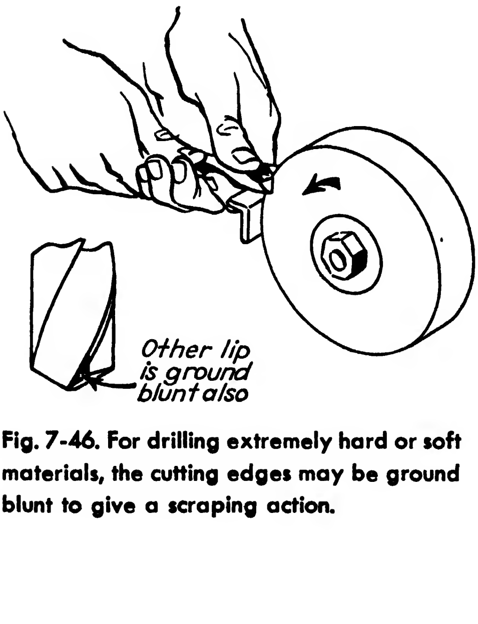


Fig. 7-46. For drilling extremely hard or soft materials, the cutting edges may be ground blunt to give a scraping action.

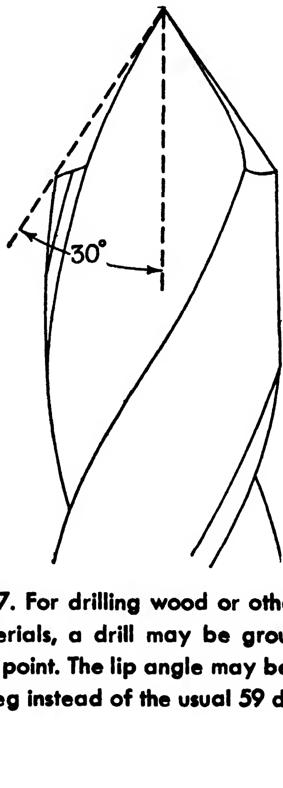


Fig. 7-47. For drilling wood or other easily cut materials, a drill may be ground to a sharper point. The lip angle may be as little as 30 deg instead of the usual 59 deg.

by using more pressure or slower motion on this last part. The heel of the cutting lip is thus ground away more. If less clearance is needed, use less pressure or a slightly faster motion toward the end of the grinding stroke. If there is a tendency to get too much clearance, possibly the drill is pointed too high up on the wheel at the beginning of the stroke.

If it is found that the two lips are not exactly the same length, then grind a little more on the short one.

Grinding a drill for soft or hard materials For drilling brass or other soft metals, or for drilling hard materials where heavy pressure is required, a drill ground with the usual shape has a tendency to gouge. To prevent this, the cutting lips may be made blunt by grinding narrow flat surfaces on the front edges, the surfaces being parallel to the axis of the drill (see Fig. 7-46). The drill then has more of a scraping action, and there is less tendency to gouge.

A drill ground in this manner is also good for enlarging holes, as from ⅜ to ½ in., or for countersinking holes to receive flathead wood screws. A regularly ground drill tends to gouge when used for such work.

For drilling wood or other easily cut materials, the lip angle may be ground much less than 59 deg—to as little, in fact, as 30 deg (see Fig. 7-47).

8. SHARPENING COLD CHISELS AND PUNCHES

Grinding cold chisels For general cutting, a cold chisel should be ground with the bevels on the cutting edge making an angle of about 70 deg with each other. For some work, such as cutting thin metal or soft metal, a keener edge may be ground.

To grind a cold chisel, grasp it firmly at such a point that when the first finger comes up against the work rest the chisel will bear against the wheel at the desired angle (see Fig. 7-48). A little experimenting may be required to determine the exact place to hold the chisel. Once it is found, keep this hold on the chisel whenever it is removed for inspection or dipping into water. The chisel can then be easily replaced on the grinding wheel at the desired angle.

Hold the end of the chisel firmly against the grinding wheel and swing it from side to side, pivoting it over the work rest (see Fig. 7-48). This grinds the corners of the chisel back a little and gives a slightly

curved cutting edge. With the corners thus rounded, there is less danger of breaking them off.

When one side of the bevel is ground smooth and even, turn the chisel over and grind the other side in the same manner. As the grinding proceeds, check to see that the desired angle of bevel is being produced. A good way is to use a sheet-metal gage (see Fig. 7-49 and Fig. 7-42). Also, dip the tool into water frequently to prevent overheating and drawing the temper.

Sometimes there is a tendency to grind the bevel longer on one edge of the blade than on the other. This is generally due to the fact

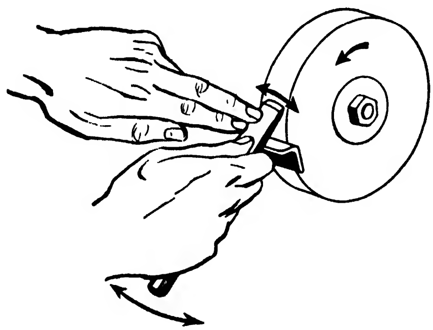


Fig. 7-48. Grinding a cold chisel. Hold the chisel firmly against the work rest, with the first finger of the right hand touching the underside of the rest. Press the cutting edge of the chisel against the wheel with the fingers of the left hand and swing the handle of the chisel back and forth with a wrist action of the right hand.

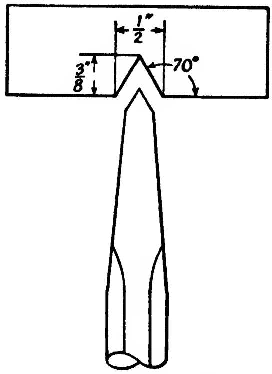


Fig. 7-49. Checking the angle of grinding on a cold chisel. For general work, the cutting end should be ground to an angle of about 70 deg. A gage for checking the angle may be made of sheet metal. (See also Fig. 7-42.)

that when the chisel was made the two opposite flat sides of the stock were not drawn out straight to form the cutting wedge. To avoid or counteract this tendency to unequal grinding, rotate the chisel very slightly about its long axis as it rests against the work rest and the wheel, thus raising one edge of the chisel off the wheel a little. Then hold it firmly in this position as it is swung from side to side in grinding.

Grinding center punches To grind a center punch, place the end flat on the work rest with the axis of the punch making an angle of about 30 deg with the grinding surface of the wheel. The point

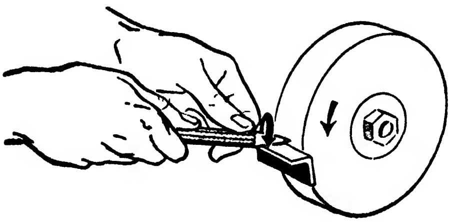


Fig. 7-50. Grinding a center punch. Hold the punch against the wheel at the desired angle and roll it slowly. Also, move it from side to side in order to distribute wear on the wheel.

will then be ground at an angle of about 60 deg, which is about right. Push the point against the turning wheel, and roll the punch slowly (see Fig. 7-50). Move the punch back and forth across the work rest to distribute the wear evenly on the grinding wheel.

Grinding pin punches If the end of a pin punch has been broken, it may be restored to shape by grinding; or if a small punch is needed and one is not available, possibly a larger punch can be ground to size and made to serve. A punch may be held against the grinding wheel and manipulated in various ways. The main points to observe are not to get the grinding wheel grooved or out of shape and to grind the punch as smoothly and evenly as possible.

9. FITTING SCREW DRIVERS

A screw driver should be ground or filed to a very blunt end. The two flat surfaces should be straight and parallel near the tip, or even slightly concave (see Fig. 7-51). The end should be square with the

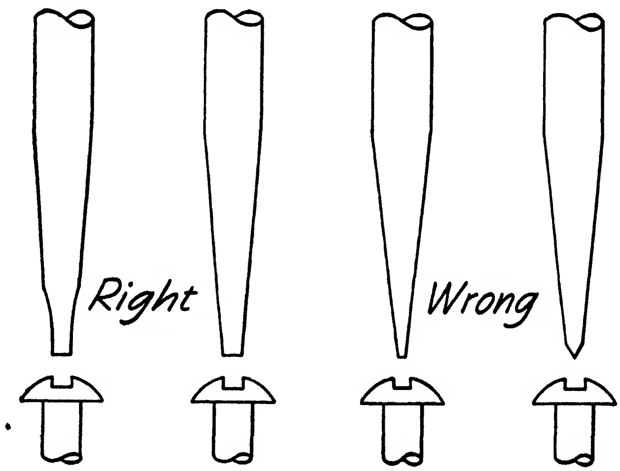


Fig. 7-51. Right and wrong shapes of screw-driver ends.

broad surfaces, and of a thickness a little less than the width of the screw slot it is to fit. It should fit the screw slot snugly. If the end is rounded or sharpened to an edge like a knife, it will easily slip from the slot and mar the screwhead.

To grind a screw driver, hold it on a grinding wheel as shown in Fig. 7-52. Move the blade endwise back and forth a little to grind the face a short distance back from the end. Turn the screw driver over, and grind the other face in the same manner. Then grind the edges and the end of the screw-driver bit. Remove the tool and inspect

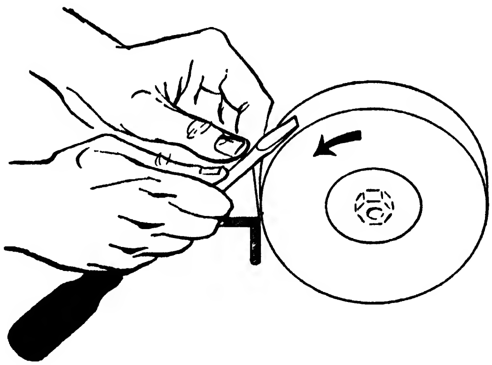


Fig. 7-52. Grinding a screw driver. Be careful to grind it to the proper shape.

it frequently to make sure that it is being ground to the desired shape. Also, dip the tool in water frequently to prevent overheating and drawing the temper.

10. SHARPENING SCISSORS AND SNIPS

To sharpen a pair of scissors or snips, grind or file the beveled edges carefully at the original angle, and then finish by whetting on an oilstone. Some scissors are too hard to file and can be sharpened only by grinding. In grinding, hold the blade at an angle across the grinding face of the wheel, with the back of the blade tilted just enough to grind at the desired bevel (see Fig. 7-53). Move the blade back and forth slowly across the wheel. If the scissors are not too dull, the beveled edges may be renewed by whetting on the coarse side of an oilstone. After the beveled edges are renewed (by filing, grinding, or whetting on the coarse side of an oilstone), finish the sharpening by whetting on the fine side of the oilstone. Be careful to keep the blades perfectly flat when whetting the flat side and at the correct angle when whetting the beveled edge.

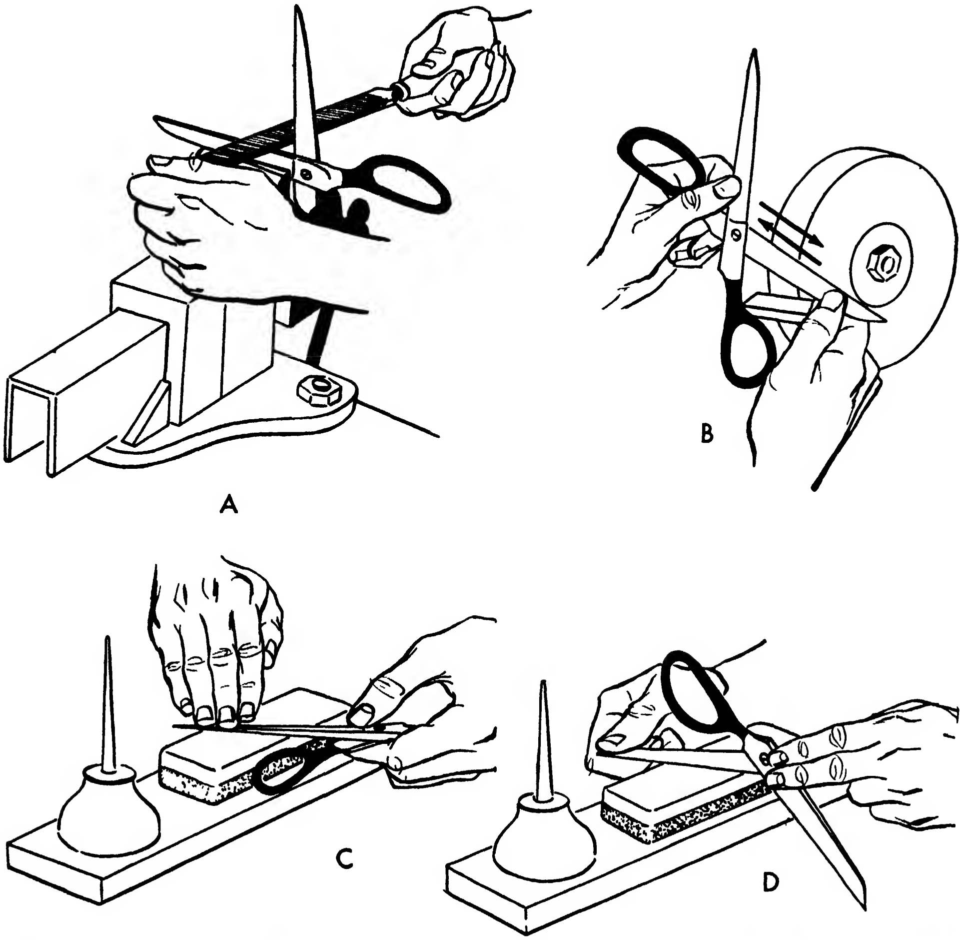


Fig. 7-53. Scissors may be sharpened by filing or grinding the beveled edges and then finishing on the oilstone, alternately whetting the flat side and the beveled edge of each blade.

11. SHARPENING HOES, SPADES, AND SHOVELS

Such tools as hoes, spades, and shovels are easily sharpened by straight filing or by drawfiling (pushing the file sidewise). Wherever possible, clamp the tool in a vise (see Fig. 7-54). If a vise is not at hand, the tool can frequently be held satisfactorily by cramping the handle against a box, a tree, or a fence post. Be careful to maintain the original angle of bevel, and be careful not to let the hands slip and come in contact with the cutting edge of the tool.

If the end of a spade or shovel has been broken or worn badly out of shape, it can often be restored by cutting the end off straight or

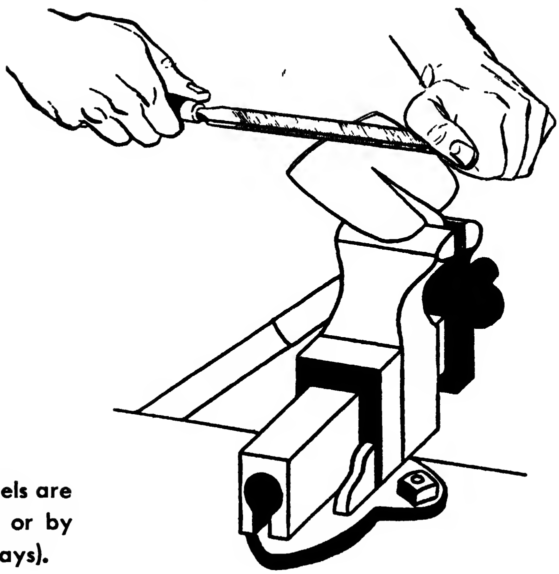


Fig. 7-54. Hoes, spades, and shovels are easily sharpened by plain filing or by drawfiling (pushing the file sideways).

to the desired shape with a cold chisel and hammer, and then dressing with a file or grinding wheel.

12. SHARPENING SAWS

Many commercial repair shops have saw-filing machines and can do a practically perfect job of saw sharpening at a reasonable cost. When such service is available, it may not be advisable to file saws by hand. With some practice and study, however, anyone with a reasonable amount of mechanical ability can learn to sharpen saws quite acceptably.

Before attempting to sharpen a saw, one should have clearly in mind the proper shape of the teeth, and it is desirable also to understand the cutting action of a saw.

Shape of saw teeth There are two principal differences in the shape of ripsaw and hand crosscut saw teeth. One difference is in the hook or pitch of the teeth. The front edge of a ripsaw tooth is perpendicular to the tooth line of the saw, while the front edge of a crosscut-saw tooth makes an angle of 15 deg with the perpendicular (see Fig. 7-55).

The second chief difference is that the crosscut-saw tooth is beveled, while the ripsaw tooth is not. In filing ripsaw teeth, therefore, the file is pushed straight across the blade; and in filing crosscut-saw teeth,

the file must make an angle with the saw blade to form the bevel. The usual angle is between 45 and 60 deg. A 45-deg angle gives a wider bevel and a keener-edged tooth, which is desirable for sawing softwood; while a 60-deg angle gives a blunter tooth that will stay sharp longer in sawing hardwood. The narrower bevel, produced by filing at about 60 deg to the blade, is usually preferred for saws in the farm shop.

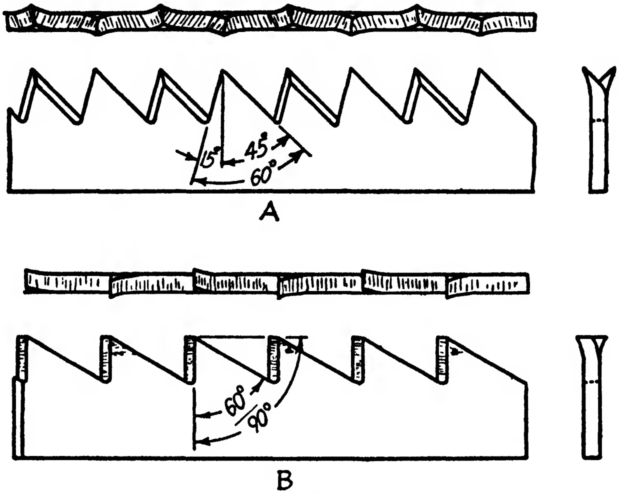


Fig. 7-55. *A,* hand crosscut saw; *B,* ripsaw. There are two chief differences in the shape of crosscut and ripsaw teeth: (1) crosscut saw teeth are beveled, while ripsaw teeth have square edges; (2) the front edges of ripsaw teeth are perpendicular to the tooth line, while the front edges of crosscut saw teeth make an angle of about 15 deg with the perpendicular.

The front edge and the back edge of a handsaw tooth make an angle of 60 deg with each other, regardless of whether it is a ripsaw or a crosscut-saw tooth.

Set of teeth It will be noted upon examining a saw that the points of the teeth are bent outward, one tooth in one direction and the next tooth in the opposite direction. This alternate bending of the teeth gives a saw what is called *set* and causes it to a cut a kerf (groove) that is slightly wider than the thickness of the saw blade, thus preventing binding or pinching.

Cutting action of handsaws The ripsaw is used for cutting wood lengthwise of the grain or fibers. The teeth act like a series of small

wood chisels following each other and cut off the ends of the fibers (see Fig. 7-56).

The crosscut saw, of course, is used for cutting across the grain or fibers. It first makes two parallel incisions with the points of the

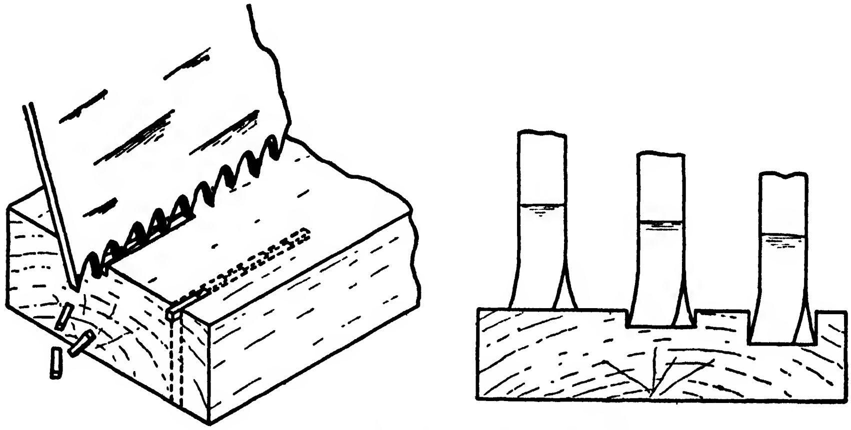


Fig. 7-56. Cutting action of a ripsaw. The teeth, acting like a series of small chisels following each other, cut off the ends of the fibers.

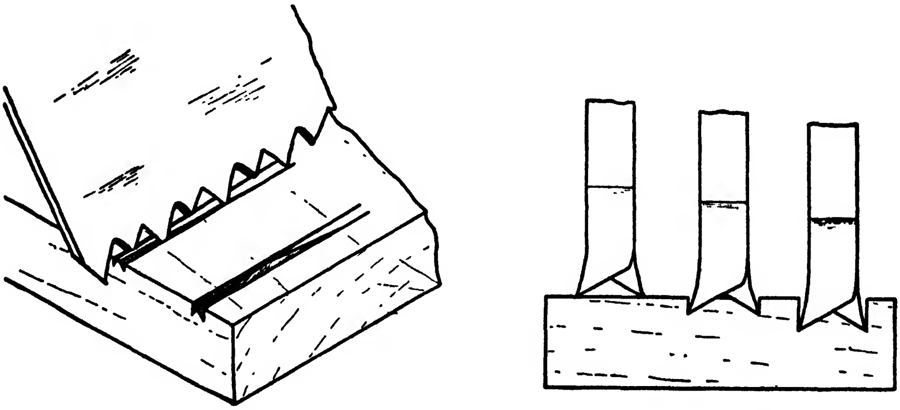


Fig. 7-57. Cutting action of a hand crosscut saw. The points of the teeth make two parallel cuts, severing the fibers.

teeth, thus severing the fibers, and then forces out the wood between the incisions in the form of sawdust (see Fig. 7-57).

Sharpening a handsaw There are three chief operations, or steps, in fitting a handsaw, namely, (1) jointing, (2) setting, and (3) filing. A fourth operation, that of side dressing or side jointing, may be performed but is generally omitted.

Jointing a handsaw Jointing has a twofold purpose: (1) to make the teeth all the same length and (2) to serve later as a guide to indicate when the teeth are filed enough. A good job of saw fitting is often spoiled by filing some teeth too much. Jointing leaves a flat

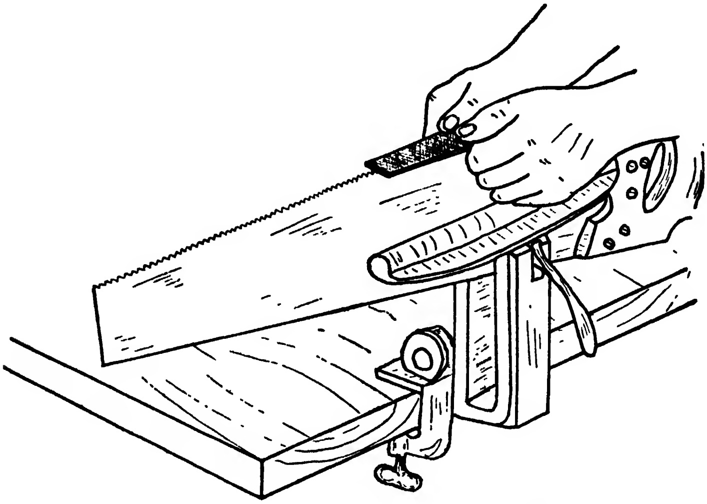


Fig. 7-58. A saw may be jointed with a file held in the hands if care is used to keep it square with the saw blade.

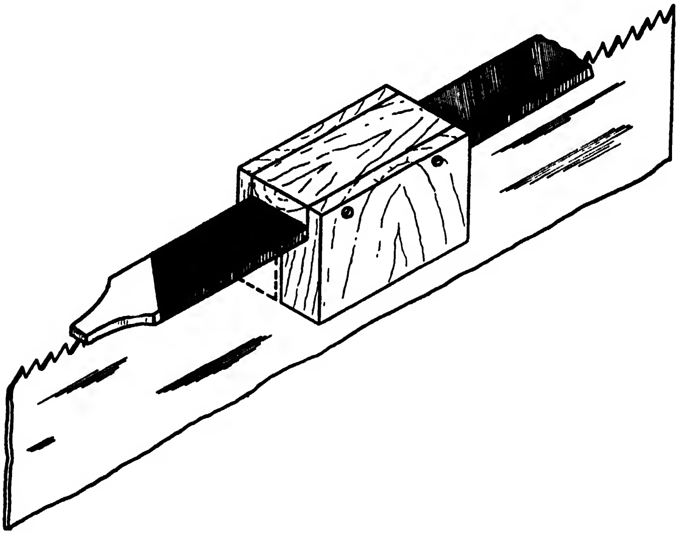


Fig. 7-59. A homemade holder for holding the file while jointing a saw.

shiny surface on the point of each tooth. When this surface *just* disappears in filing, the tooth is sharp and should not be filed further.

To joint a saw, run a mill (flat-type) file over the ends of the teeth, lengthwise of the saw. Be very careful to keep the file square with

the saw blade. This can be done by grasping the file in both hands and holding it by the edges, thumbs on top and first fingers underneath (see Fig. 7-58). A wooden square-edged block or a special tool may also be used to hold the file in the proper position (see Fig. 7-59).

File the tooth line straight, or curve it out slightly in the middle of the saw to give it a "breast" effect. File until there is a small shiny point on the end of each tooth, except possibly an occasional very short tooth.

Many experienced mechanics omit jointing when the saw teeth are uniform in length and when they require only light filing. By filing every tooth the same number of strokes, they are able to keep the teeth uniform in length without first jointing them.

Setting a handsaw After jointing, the saw teeth are next set, unless they are very uneven in shape and size. In this case, the teeth should be filed to approximately the correct shape and size before setting and then filed again after setting.

A saw need not be set every time it is filed, particularly if only a light filing is required. A saw can sometimes be filed two or three times before it needs to be reset.

Setting is commonly done with a small tool known as a *spring saw set*. To use it, simply place the set over a tooth and squeeze the grips or handles. Use only moderate pressure, and do not raise up or yank on the handles. Too much pressure may mash the end of the tooth out of shape, and raising up on the handles may give the tooth too much set. When the handles are squeezed, a small plunger is forced against the end of the tooth, bending it over against a small anvil.

To set a saw, place it in a saw vise or clamp with the teeth projecting an inch or two above the jaws of the clamp. Begin at one end of the saw, and set every other tooth, using the spring saw set (see Fig. 7-60). Be sure to bend the teeth in the same direction they were originally set in. When half the teeth are set, reverse the saw in the clamp and set the remaining teeth.

Most saw sets are adjustable, and when using one with which you are not familiar, it is best to set a few teeth and then examine them closely before setting the whole saw. If the teeth are set too much, or not enough, adjust the tool accordingly.

Only about one-third to one-half the length of a tooth should be bent in setting. If the depth of set is more than this, some teeth may be broken out, or the blade may be kinked or cracked.

The amount of set that a saw should have depends upon the kind of wood to be sawed and upon the thickness of the saw blade above the teeth. The better saws are ground thinner above the teeth and therefore require very little set. Green or wet wood will require more set than dry, well-seasoned wood, and softwoods more than hardwoods. For average work, bending the teeth out about 5/1000 in. should be

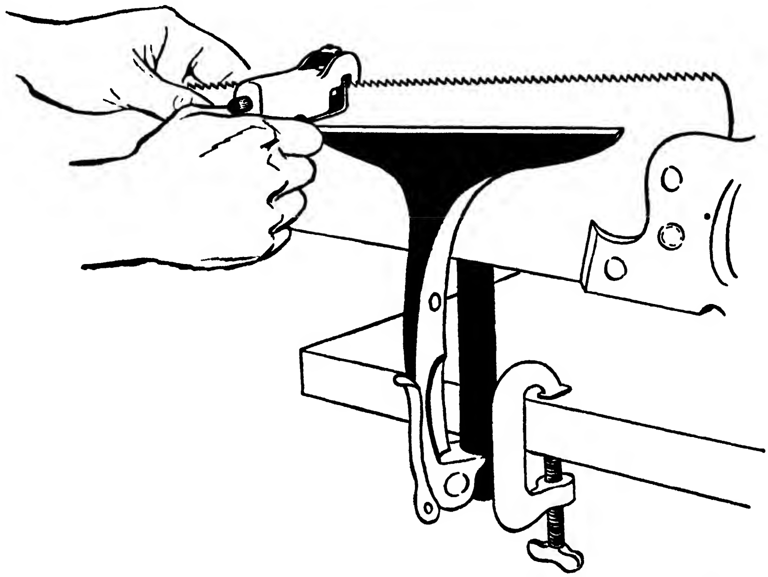


Fig. 7-60. Setting a saw with a spring saw set. Set half the teeth from one side; then reverse the saw in the clamp and set the other half.

ample. Too much set causes the saw to cut too wide a kerf, resulting in poorer control of the saw and extra work to push it. Too little set causes pinching or binding in the kerf.

Filing a hand crosscut saw Clamp the saw securely in a saw vise or clamp with the teeth projecting between 1/8 and 1/4 in. above the jaws—just enough for the file to clear the jaws easily. If the teeth project too far above the clamp, the saw will chatter and the file will screech. A clamp made of two 1 by 4s and used in an ordinary vise is satisfactory (see Fig. 7-61).

For best results, the top of the saw clamp should be at about the height of the armpits or possibly an inch or two lower. One must be constantly on guard while filing to maintain the desired shape of teeth, and this can best be done when the sides of the teeth are easily seen; hence the rather high position of the saw while filing it.

In order to avoid eyestrain and to ensure a good job of filing, *good light is absolutely essential.* It is usually best to work in front of a window, where the light will shine on the teeth and it will be easy to see the reflections from the small shiny surfaces left by jointing. If a lamp is needed, it should be placed above and a little in front of the workman. The light rays should shine down on the saw teeth (see Fig. 7-62).

The kind and size of file to use depend upon the size of the saw teeth and the preference of the mechanic. In general, 6-in. slim-taper

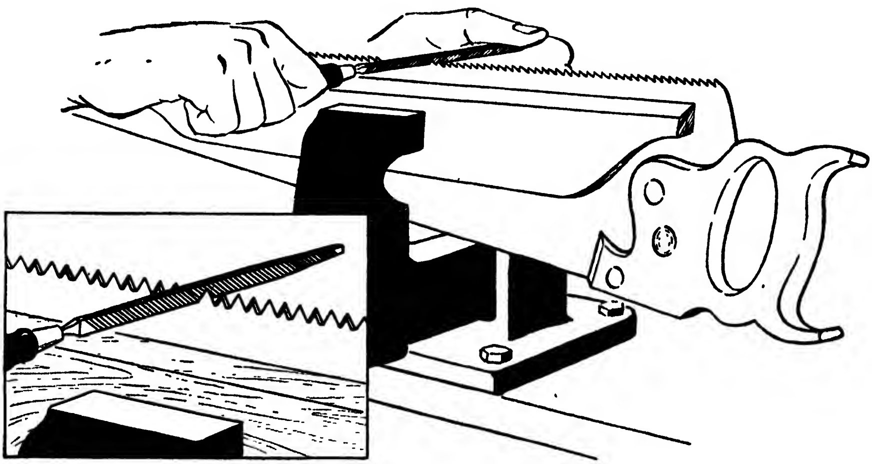


Fig. 7-61. Filing a crosscut saw held in a homemade clamp and machinist's vise.

saw files are recommended for saws with seven to nine points per inch, and 7-in. slim-taper files for saws with five to six points per inch. Some mechanics prefer blunt files instead of tapered ones.

The following points are important in manipulating the file:

1. Hold the file handle in the right hand (assuming the workman is right-handed) and only moderately tight.
2. Hold the tip of the file lightly between the thumb and first finger of the left hand.
3. Exert pressure on the forward strokes only.
4. Lift the file slightly on the return strokes, or at least release the pressure.
5. Make long, slow cutting strokes—not short, fast ones.
6. Keep the file level or pointed up very slightly if necessary to prevent screeching.
7. Use enough pressure to make the file cut, but no more.

If the file slides along without cutting, try a little more pressure and a slower stroke. Be sure to release the pressure on the backstroke. If this does not make the file cut, it is probably dull and should be discarded.

Fig. 7-62. For best results, clamp the saw at about the height of the armpits and work in a good light.

First position Study Fig. 7-63 very carefully to get the proper starting position for filing a saw. The following points are important:

1. Place the tip end of the saw in the saw clamp with the handle to the right.
2. Find the first tooth in the end of the saw that is bent out toward you. Place the file in the first gullet (V notch between two teeth) to the left.
3. Point the file across the saw blade at an angle of about 60 deg and with the point toward the saw handle.
4. If the teeth are of the proper shape (see Fig. 7-55), press the file firmly down into the gullet and let it find its own bearing against the two teeth. If the front edges of the teeth are not about 15 deg from the vertical, however, rotate the handle of the file so that the front edges will be filed at this angle.

5. Keep the file level, or pointed upward a little if necessary to prevent screeching.
6. Push the file forward, cutting the front edge of one tooth and the back edge of the adjacent one.
7. Lift the file slightly on the backstroke, or at least release the pressure.
8. File until about half the flat shiny surfaces made by jointing are filed away.
9. Then move the file two gullets to the right (toward the saw handle), and file in a similar manner. Continue filing every other gullet until you reach the handle.
10. Inspect your work frequently to be sure you are getting the teeth properly shaped. Remember that the front edges should be about 15 deg from the vertical. This angle is changed by rotating the file handle slightly in the hand.

Second position When half the teeth have been filed from the first position, turn the saw around in the clamp with the handle to the left (*B*, Fig. 7-63). Find the first tooth in the end of the saw that

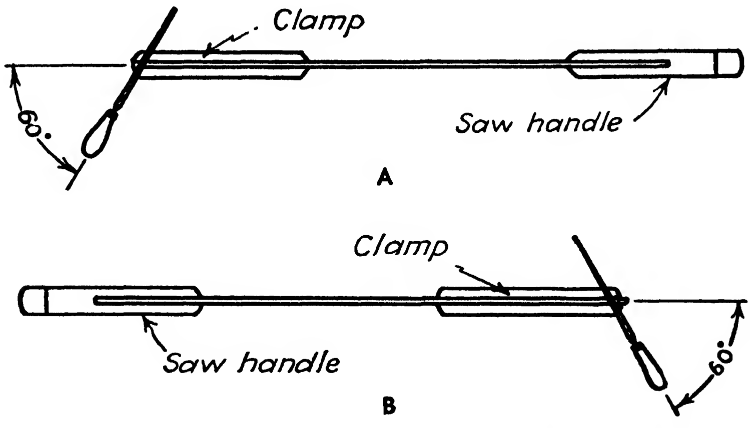


Fig. 7-63. The two positions for filing a hand crosscut saw; A, first position—begin at the tip of the saw and work toward the handle. Hold the file at an angle of about 60 deg to the saw blade and be sure that the file cuts the front edge of each tooth at an angle of about 15 deg from the vertical. B, second position—after half the teeth are filed, turn the saw around in the clamp and file the other half from the other side.

is set out toward you, and place the file in the first gullet to the right. Point the file at an angle of about 60 deg across the saw blade and toward the saw handle. File in a manner similar to that used in the

first position, filing in every other gullet until the handle of the saw is reached.

It is better to make about the same number of strokes with the file in each gullet, even though not quite all the flat shiny surfaces (left from jointing) are removed. Some of these shiny surfaces may well be left until the final touching up.

Touching up After going over all the teeth once, examine the saw carefully to see if any blunt shiny points still remain from jointing. If they do, as they most likely will, then place the saw in the first position again (*A*, Fig. 7-63), and go over the saw, filing *only those teeth which have shiny points.* Then reverse the saw, placing it in the second position again (*B*, Fig. 7-63), and go over the saw, filing only those teeth which have shiny points. In a similar manner, go over the saw three or four times, if necessary, filing only the teeth that have shiny points, until all teeth are sharp.

Keeping proper shape and angle of teeth It is very important that the front edges of the teeth be filed to a pitch of about 15 deg from the vertical. It is important also that the file be held at a uniform angle of about 60 deg with the saw blade in order to produce the proper bevel. By placing the file in a gullet between two properly filed teeth and letting it seek its own position, the desired angles for filing can be determined. One must be constantly on guard, however, to keep this position after it is established.

A common trouble among beginners is to file the teeth in pairs with a broad short tooth next to a long slim one. This trouble is usually caused by failure to maintain the proper slope of about 15 deg on the front of each tooth. To correct the trouble, therefore, first be sure that the file is held so as to give the proper angle, and then press it firmly against the broad tooth and lightly, if at all, against the narrow one, as it is pushed through the gullet between them.

Filing a ripsaw The same general procedure is used for filing ripsaws as for hand crosscut saws. There are two points of difference, however, that need to be kept in mind: (1) The front edges of the teeth are perpendicular to the tooth line instead of at an angle of 15 deg from the perpendicular. (2) The edges of the the teeth are not beveled but are square with the saw blade (see Fig. 7-55).

Except for the difference in angles of filing required by these two differences, a ripsaw is filed exactly the same as a crosscut saw.

Side dressing or jointing a handsaw To side dress or side joint a saw, lay it on a flat board or bench and rub the sides of the saw teeth with the edge of an oilstone or with a fine file. The objects of side dressing are to smooth any rough edges left from filing and to even up the set in the teeth. Side dressing is usually not necessary for general sawing.

If, when a saw is tried, it is found to be set unevenly and tends to run to one side of the line, it may be side dressed on the side that leads away from the line. Side dressing may also be used to reduce the amount of set in case the saw cuts too wide a kerf.

Points on sharpening handsaws

1. Always work in a good light so that the points of the teeth may be easily seen.
2. Set only the points of the teeth—not more than one-third to one-half the length of the teeth.
3. Work with the saw at about the height of the armpits.
4. Clamp the saw with $\frac{1}{8}$ to $\frac{1}{4}$ in. projecting above the jaws of the clamp—just enough to allow the file to clear the jaws of the clamp.
5. File on the forward stroke only. Lift the file slightly, or at least release the pressure, on the backstroke.
6. Use long, slow, rhythmic strokes. If the teeth are reasonably uniform in shape and size, file each gullet about the same number of strokes.
7. Just barely file away the flat shiny surfaces on the points of the teeth left by jointing.
8. Have no slope on the front edges of ripsaw teeth. Make them perpendicular to the line of teeth.
9. Slope the front edges of crosscut saw teeth about 15 deg from a perpendicular to the line of teeth.
10. In filing a crosscut saw, point the file toward the handle of the saw, keeping the angle between the file and the saw blade at about 60 deg.
11. In filing a ripsaw, file straight across, keeping the file at right angles to the saw blade.
12. Do not point the file upward or downward, but keep it level, unless

the file screeches; elevating the point slightly will stop the screeching.

13. If the teeth tend to become uneven in size, first be sure the file is held to give the proper slope on the front edges of the teeth, and then press harder against the big ones and lightly or not at all against the small ones.

Sharpening bucksaws and pruning saws The same general principles used in setting and filing crosscut handsaws apply in setting and filing bucksaws and pruning saws. The shape and angles of the teeth of bucksaws and pruning saws are different from those of handsaws, however, and therefore the file must be held differently when filing them. The proper shape of teeth can be determined by looking at some of the teeth near the ends of the saw that have not been used a great deal. Holding the file firmly between two of these teeth near the end of the blade will give the correct angles for filing.

Sharpening crosscut timber or log saws To sharpen timber or log saws, one should have a combination jointer and raker gage and a saw set for such saws. It is possible, however, to set a log saw with

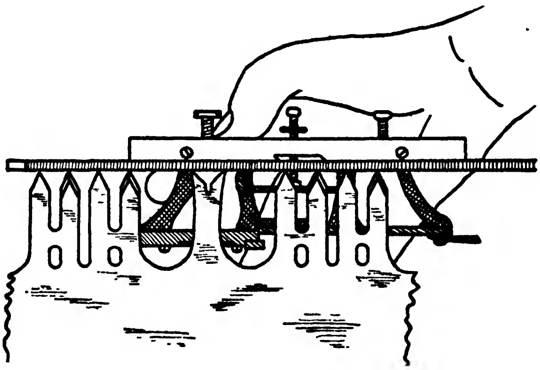


Fig. 7-64. Jointing a crosscut log saw.

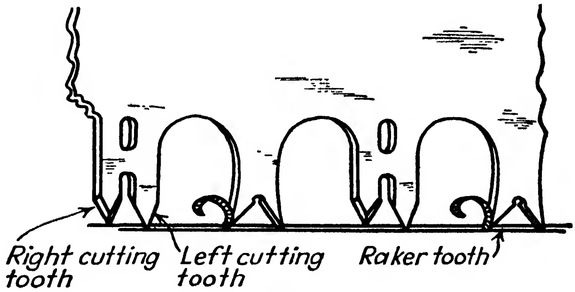
a hammer and setting block. A mill (flat-type) file about 8 in. long is used to file the teeth.

The operations or steps in fitting a log saw are: (1) jointing, (2) filing down the raker teeth, (3) setting the cutting teeth, and (4) filing the teeth.

Jointing To joint a log saw, place a file in the jointing tool (see Fig. 7-64) and file down the teeth until the shortest of the cutting teeth

is reached. If the saw is in fair shape, very light jointing is all that is required. It is very difficult to hold a file in the hands and joint the teeth of a log saw, because the teeth are too long.

Filing down the rakers The rakers, or those teeth which shave off and carry out the wood between the two parallel incisions made by the cutting teeth, should be a little shorter than the cutting teeth, the exact amount varying with the kind of wood to be sawed. In general, they should be about 1/64 in. shorter for hardwoods, and about 1/32 in. shorter for softwoods. To file down the rakers, place the raker gage on the saw and file down the points of the rakers even with the gage (see Fig. 7-65).



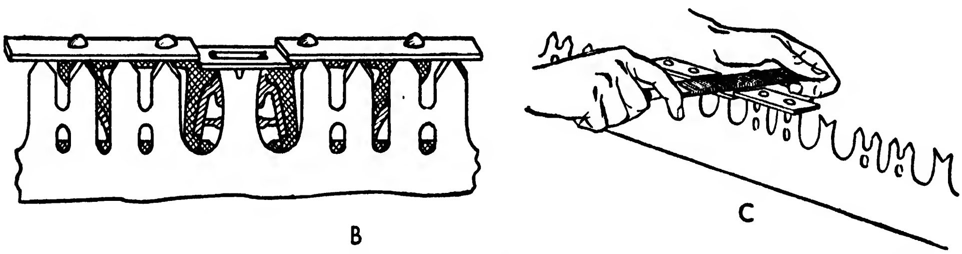


Fig. 7-65. A, how a crosscut log saw works. The right and left cutting teeth make incisions, and the raker teeth cut out the wood between the incisions. *B* a raker gage in place ready to file down the rakers. C filing down the rakers. File them 1/64 to 1/32 in. shorter than the other teeth.

Setting the teeth The teeth may be set with a hammer and setting block or with a spring saw set. Many prefer the spring set. Not more than 1/4 in. on the end of a tooth should be bent. A homemade setting block can be made easily by filing a corner of a piece of iron as shown in Fig. 7-66.

Filing the teeth File the rakers on the inside of the end notch with a mill file. The angle at the center of the notch should be about a right

angle and may be checked with the square end of the file (see Fig. 7-67). Be careful not to file the teeth shorter than the length to which they were jointed. It is a good practice to file half the rakers from one side of the saw and the other half from the other side.

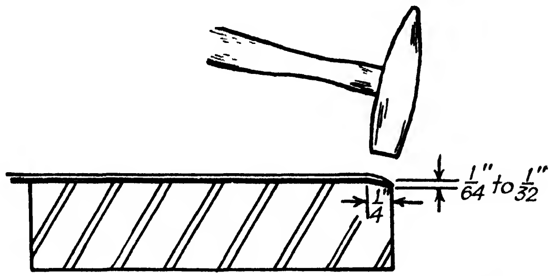


Fig. 7-66. A homemade setting block for setting timber or log saws.

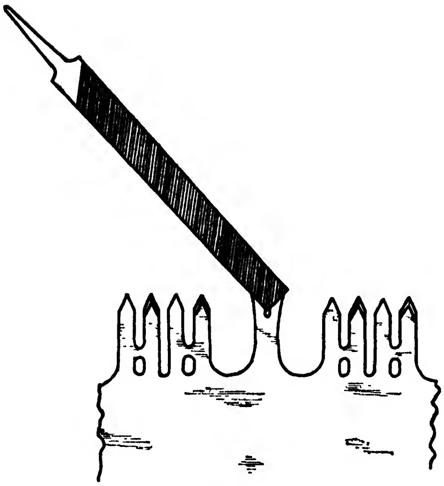


Fig. 7-67. File the gullets of the raker teeth so that the square end of the file will fit. Be careful not to file the rakers too short.

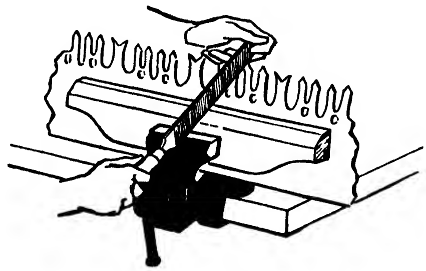


Fig. 7-68. Filing the cutting teeth of a crosscut log saw.

File the cutting teeth in much the same manner as the teeth of a crosscut handsaw (see Fig. 7-68). File half the teeth from one side of the saw and half from the other. The proper angle of the points and the width of the bevel on the cutting teeth depend upon the kind of wood to be sawed. For softwoods, a long point with a wide bevel is recommended, and for hardwoods or knotty or frozen wood, a blunter point with a narrower bevel.

Gumming a log saw After several filings, the gullets between the teeth of a log saw become so shallow that they cannot well hold all the sawdust made by the teeth. Consequently, the sawdust binds against the sides of the saw kerf and makes the saw pull hard. The saw should then be gummed, that is, the gullets should be filed or ground deeper. It is a very slow, tedious job to gum a saw with a file. The best method is to use a special thin grinding wheel made for this purpose. A special stand or work rest can be made in front of the grinder to support the saw while it is being gummed. It is best not to do all the gumming in a gullet at one time, but to grind a little in one gullet and then proceed to the next, going over the saw three or four times to complete the job. This avoids overheating the saw and drawing the temper.

Sharpening circular saws In sharpening a circular saw, the same general operations are performed as in fitting a handsaw or log saw. The operations or steps are: (1) jointing or truing up, (2) gumming, if needed, (3) setting, and (4) filing. Not all these operations need be done every time a saw is fitted.

Jointing A circular saw is jointed to make it truly circular, or to make the tooth points all the same distance from the center of the saw. Jointing is usually best done by leaving the saw mounted on its own shaft and turning it slowly backward by hand while holding a file firmly yet lightly against the ends of the teeth. An easy method of holding the file in the proper position is to adjust the saw so that the teeth barely project through the slot in the saw table and then hold the file on the table over the slot.

Gumming A circular saw may be gummed in the same manner as a log saw. It may be done with a round file or with a flat file with a round edge; but a much easier way is to use a special saw-gumming wheel. Circular saws with certain kinds of teeth, such as fine-toothed crosscut saws, do not require gumming.

Setting The teeth of a circular saw may be set with a hammer and setting block or with a large spring saw set. The amount and depth of set required will depend upon the kind of saw, whether it is a ripsaw, a cutoff saw, a cordwood saw, etc., and upon the kind of wood to be sawed. If, after a saw is fitted, it is found to bind in the saw kerf, it is a simple matter to give it a little more set.

Some circular saws require no set, because they are hollow- or taper-

ground from the rim toward the center so as to provide clearance for the teeth without set. Small circular saws of the combination type are often taper-ground.

Filing The kind of file to use in filing a circular saw will depend on the shape and size of the teeth. For a crosscut saw, usually a three-cornered file about 8 in. long is used. For a ripsaw or a cordwood saw, a mill (flat-type) file about 8 or 10 in. long is used.

In filing a circular saw, be careful to preserve the original angle of bevel and the original pitch of the teeth. The proper position for the file can be determined by pressing the file into a gullet, or against the side of a properly filed tooth, and allowing it to "seat" against the tooth.

Some mechanics make paper patterns showing the exact shape, size, and angles of teeth of new saw blades and keep them to serve as guides in refiling. Another good practice often followed is to keep an extra saw blade or two, so that in case one is accidentally dulled, a sharp one can be put on the saw immediately. The dull one then can be refiled at a convenient time, or sent to a commercial shop for sharpening.

13. REPLACING HANDLES IN TOOLS

Tools with broken handles are sometimes discarded when they could be restored to practically perfect condition by simply replacing the handles. Although new handles can be made by a careful workman, it is usually much more practical to buy the handles ready to be put on the tools. Fortunately, it is usually possible to buy handles that can be fitted to the tools with a minimum of time and work and with the assurance that they will fit satisfactorily.

Tightening loose handles Handles of tools like hammers, axes, and hatchets often become loose and simply need to be retightened. This is usually an easy job and can be done by first driving the handle tightly into the head of the tool (see Fig. 7-69), and then driving the wedges tighter into the end of the handle. Another practical way of tightening the handle into the head is to ram the handle endwise down against a bench or some other solid object (see Fig. 7-70). Steel wedges for driving into the end of the handle and expanding it in the eye of the tool are usually available at hardware stores. Steel wedges with roughened sides are easily made in the shop, as are wooden wedges. Either

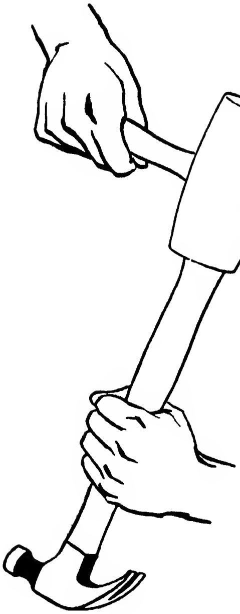


Fig. 7-69. Tightening a hammer handle by driving on the end of the handle.

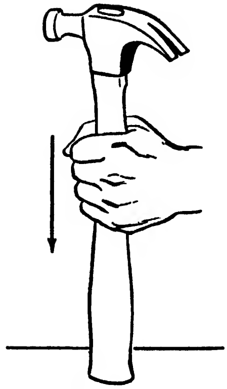


Fig. 7-70. A hammer handle may also be tightened by ramming the handle down against the bench top.

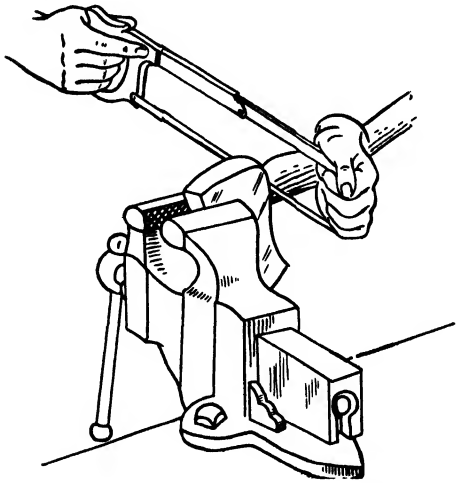


Fig. 7-71. To remove a broken handle from an ax, first saw close to the head with a hack saw.

type is satisfactory, provided it is of suitable size and is carefully made and driven into place.

Replacing tool handles To replace broken handles in tools like hammers and axes, first remove the pieces of broken handle from the tool head. A good method is to saw close to the tool head with a hack-

saw (see Fig. 7-71) and to remove the wood from the eye by first drilling with a metal-drilling twist drill (see Fig. 7-72), and then punching as may be required. When the old handle has been removed, carefully work the end of the new handle down to size with a rasp (see Fig. 7-73), trying the handle in the head frequently as the work

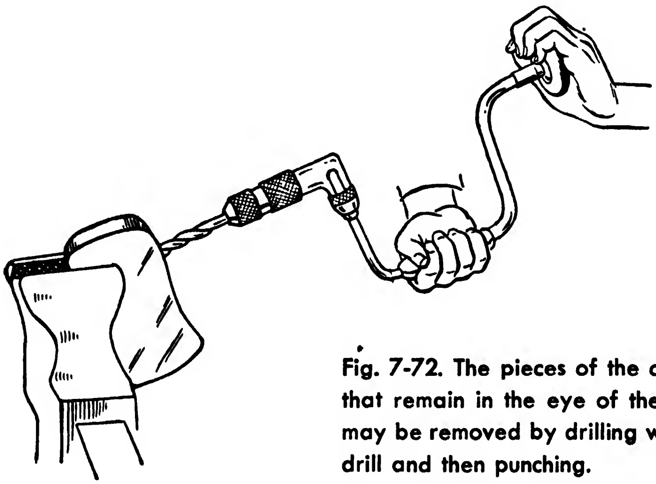


Fig. 7-72. The pieces of the old handle that remain in the eye of the ax head may be removed by drilling with a twist drill and then punching.

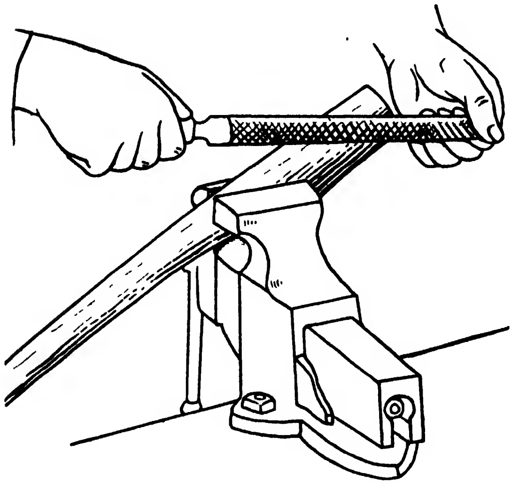


Fig. 7-73. Work the new handle down to size with a rasp. Frequently try the handle in the head of the ax for fit as the work progresses.

progresses. A rasp is preferred to a plane or drawknife, as such tools tend to follow the grain and are more difficult to control. In fitting a new ax handle, the head should fit back to within ½ to ¾ in. of the biggest part of the handle. It is also important that the handle be so fitted that when the ax is held vertically on a bench with the end of

the handle touching the bench the cutting edge will touch at a point about two-thirds its length from the outer end (see Fig. 7-74).

After the end of the handle is worked down to size, rip the end (see Fig. 7-75), if a wooden wedge is to be used. The ripped part should extend a little more than halfway through the head when the handle is put in place.

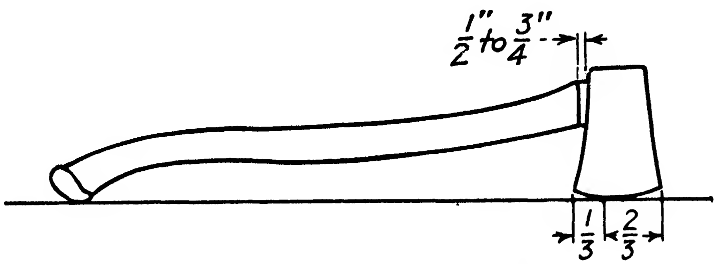


Fig. 7-74. The handle should be fitted so that a straight line from the end of the handle tangent to the cutting edge of the ax head will touch the edge at a point about two-thirds of its length from the outer end.

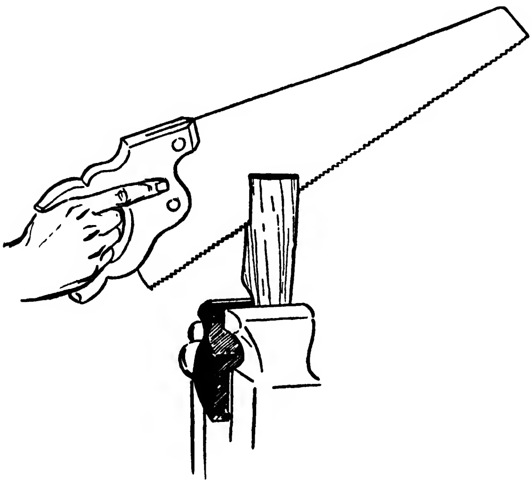


Fig. 7-75. After fitting the end of the handle, rip a kerf for the wedge if a wooden wedge is to be used.

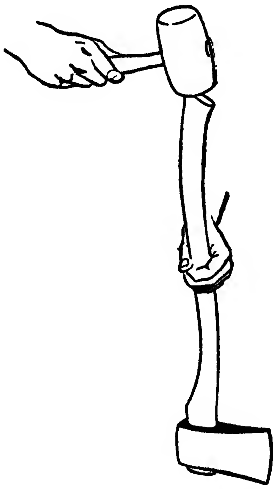


Fig. 7-76. Driving the fitted handle tightly into place.

Next, drive the handle firmly into place, using a mallet (see Fig. 7-76). If the grip on the end of the handle is not round or knob-shaped, but is of the style that is cut off at an angle, there may be some danger of splintering or marring it with a mallet. This danger may be largely avoided by chamfering or rounding the end somewhat with a file

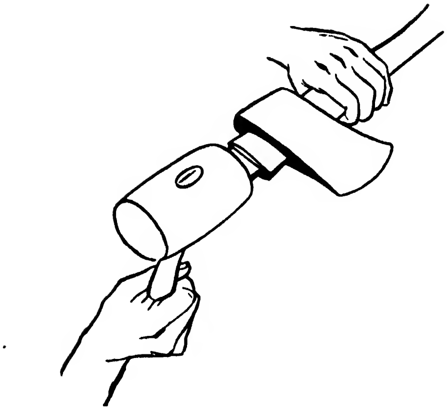


Fig. 7-77. Driving a wooden wedge into the kerf in the end of the handle.

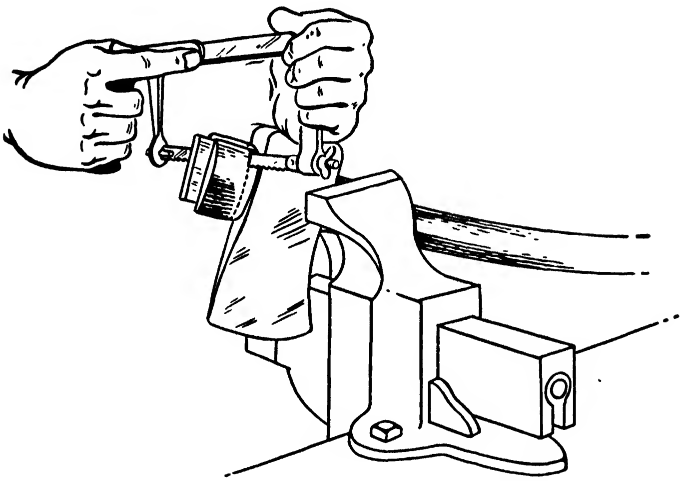


Fig. 7-78. After the handle is fitted and tightly wedged in place, saw off the protruding part of the handle and wedge with a hack saw.

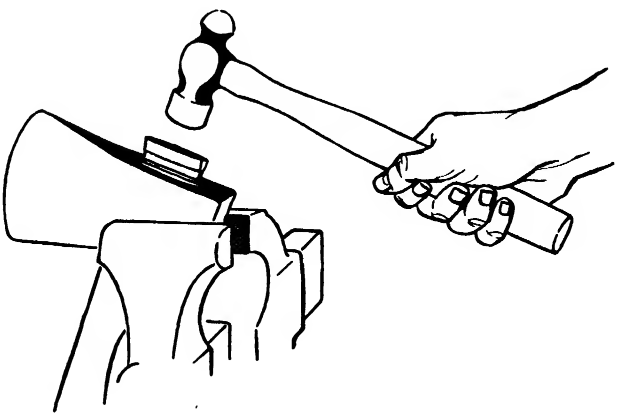


Fig. 7-79. Fastening the ax handle with a steel wedge.

before driving with the mallet. After the handle is driven into place, make a thin wooden wedge and drive it tightly into the end of the handle (see Fig. 7-77). Then saw off the end of the handle and wedge with a hack saw, leaving about ¼ in. projecting beyond the ax head (see Fig. 7-78). The projecting part swells and helps keep the handle tight. If steel wedges are used, the end of the handle need not be ripped, as the wedges can be driven into place after the handle has been cut off even with the head.

Replacing shovel handles The procedure for replacing a shovel handle will depend somewhat upon the type of handle used. Most handles are held in place by rivets. To remove the old broken handle, cut

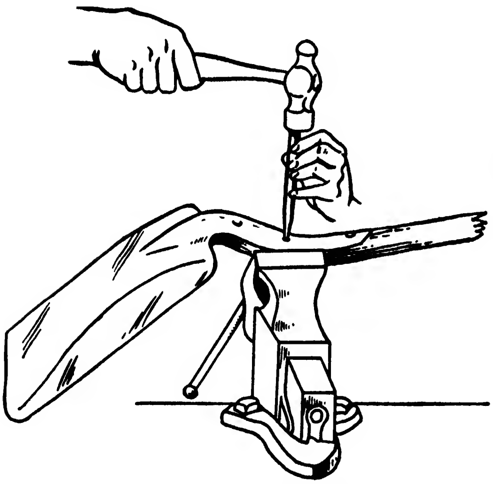


Fig. 7-80. To remove a broken shovel handle, grind or cut off the heads of the rivets and remove them by punching.

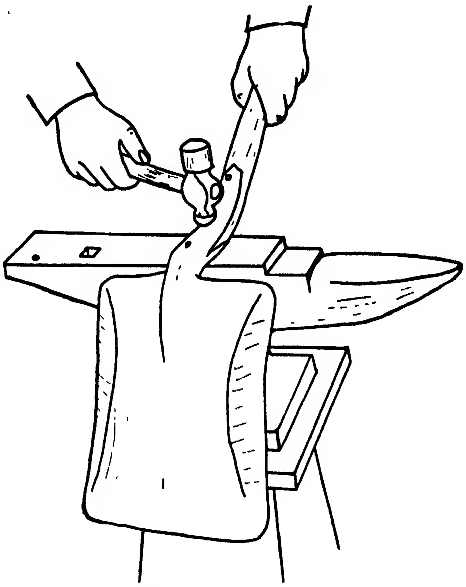


Fig. 7-81. After fitting a new shovel handle, drill holes, insert rivets, and hammer the rivet heads down.

off the rivet heads by grinding, by cutting with a sharp cold chisel, or by sawing with a hack saw, and then drive out the rivets (see Fig. 7-80). Next, fit the new handle, drill holes for the rivets, insert them, and hammer the ends down with a ball-peen hammer. Strike one or two heavy blows first with the flat face of the hammer, and finish by light peening with the ball peen (see Fig. 7-81). It is usually possible to buy

new handles that require little or no fitting, other than the drilling of the holes.

Replacing fork handles It is usually possible to buy fork handles complete with metal ferrules and with the ends bored, so that all that is required in replacing a broken handle is simply driving the fork from the old handle and driving it into the new one (see Fig. 7-82). If

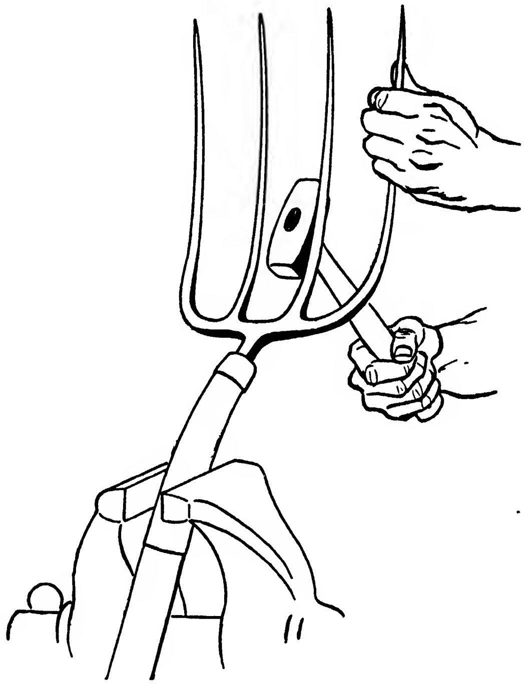


Fig. 7-82. Most fork handles can be replaced by driving the fork out of the end of the old handle and driving it into the end of the new handle.

such fitted and bored handles are not available, the ferrule or straps can be removed from the old handle and mounted on the new one after the end is trimmed to fit. The end of the handle is then carefully bored or drilled to a suitable size. If in doubt as to the proper size of bit, use one that is too small rather than too large, and if necessary, enlarge the hole later with a larger bit. The fork should fit very tightly, yet it should not split the handle.

Replacing hoe and rake handles The style of hoe or rake will suggest the exact method of replacing a broken handle. The general

procedure is the same as for forks and shovels. Sometimes the handles of garden tools, like hoes and rakes, break off where they fit into the socket or ferrule. In such a case, it is frequently practical to remove the pieces of wood from the socket or ferrule and to refit and use the old handle. Care should be taken to make the end of the old handle fit snugly into the socket or ferrule.

In the case of a tool attached to the handle by means of a slightly tapered square tang driven into the end of a handle, it is sometimes advisable to drill a small hole straight through the end of the handle—ferrule, tang, and all—and insert a small rivet. This keeps the tool from pulling off the handle.

Replacing a handsaw handle The best way to repair a saw with a broken handle is to remove the handle and install a new one. To install a new one, carefully mark and drill the holes through it, and fasten it in place with the special screws used on the original handle. A new handle can be made in the shop if necessary. To do this, lay the old handle on a piece of suitable wood, and mark out the shape with a pencil. Then saw out the handle approximately to shape with a coping saw, compass saw, or band saw, and finish with rasp, files, scraper, and sandpaper. Carefully saw the kerf to receive the end of the saw blade, and attach the handle as outlined above for a new handle.

14. CLEANING TOOLS

If grime, dirt, and grease accumulate in use, the tools should be cleaned by wiping with a cloth moistened in gasoline or kerosene. Tools that have become rusty may usually be cleaned by rubbing with a rubbing compound used in automobile repair shops for finishing painted surfaces. This is a rather mild abrasive and will not scratch like emery cloth or sandpaper. For long-neglected and badly rusted tools, it may be necessary to resort to faster-cutting abrasives like emery or sandpaper. In such cases, it is well to finish with a fine rubbing compound.

Another abrasive that may be used is pumice stone. It may be applied to a moistened cloth and then rubbed on the tool. This is a good way to clean a rusty saw (see Fig. 7-83). After such treatment, the tool should be dried thoroughly and then given a light coat of oil. Wiping tools occasionally with an oily rag helps to keep them from rusting.

A rotary wire brush or a buffing wheel on a small motor-driven grinder is excellent for removing rust and polishing tools (see Fig. 7-84).

Commercial liquid rust removers are available at some hardware and supply stores, as well as rust preventive or inhibiting oils which

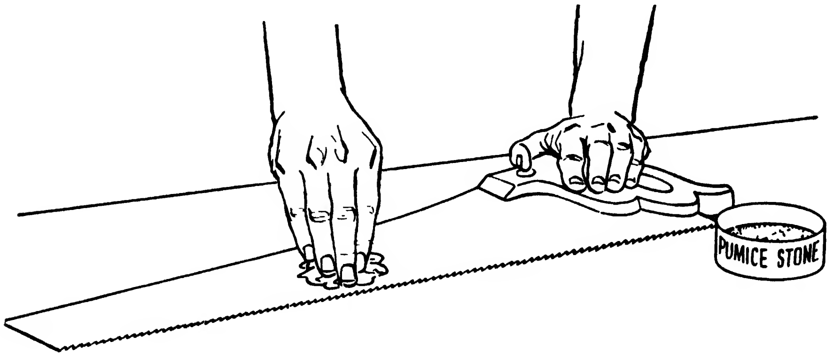


Fig. 7-83. A rusty saw may be cleaned by rubbing with pumice stone and water, after which it should be wiped dry and oiled.

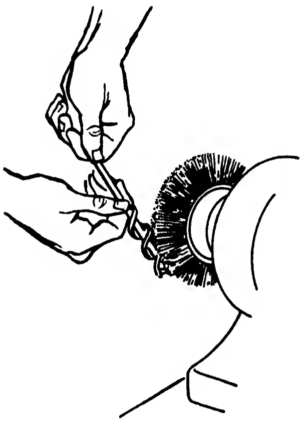


Fig. 7-84. A rotary wire brush is excellent for removing rust and for cleaning many tools.

may be applied to tools. Some of these might well be used in the farm shop. Give tools to be stored for long periods a light coat of some kind of rust-inhibiting grease.

JOBS AND PROJECTS

1. Learn how to sharpen a pocketknife quickly and easily. (A blade in fair condition can usually be made really sharp in three or four

minutes.) If you carry a pocketknife make it a practice to keep at least one blade very sharp, possibly even sharp enough to shave with.

2. Make a study of the grinders in shops. Note the methods of adjusting the work rests, wheel guards (if any), and bearings (if adjustable). Are the bearings easily and conveniently lubricated? Are safety-glass eye shields used? If not, could they be installed easily?

3. Of about what grain size are the grinding wheels? Do the wheels appear to be of about the proper grade for the grinding that has been done on them? What are indications of too hard a wheel, and of too soft a wheel?

4. Do any of the grinding wheels need dressing? How may one tell when a wheel needs dressing? Dress a wheel if you find one that needs it.

5. Adjust the work rest on a grinder. How close should the rest be to the wheel? Why should a rest be kept carefully adjusted?

6. Inspect the axes and hatchets about your home or farm. If any need new handles or need sharpening, take them to the shop and put them in first-class condition.

7. Inspect other keen-edged tools, like planes, wood chisels, and drawknives, which you may have at home. If any need grinding, sharpening, or repairing, take them to the shop and put them in first-class condition.

8. Make it a point to keep all the tools you use in the shop sharp and in good working condition. If in doubt as to the method of sharpening, consult the text or your instructor.

9. Inspect the twist drills in the shop. Make a list of any defects in sharpening (grinding) that you find.

10. Grind some twist drills, making it a point to grind them properly and to avoid the common mistakes in grinding. Practice until you can grind a drill properly in two or three minutes. Whenever you start to use a drill, first inspect it, and if it needs grinding, stop and grind it. It takes just a minute or two and really saves time.

11. Compare rip and crosscut handsaws. Note the difference in the bevel on the edges of the teeth. Note also the difference in the

hook of the teeth, or the angle that the front edges of the teeth make with the tooth line. These differences are very important and must be kept in mind in filing saws.

12. Examine the saws in the shop and determine, simply by inspection if you can, which ones are sharp and which ones are dull. Try the saws, and verify your conclusions.

13. Practice saw sharpening on short practice blades if such are available in the shop. If you do not get a good job the first time, joint the teeth and try again.
    Remember that it is important to watch the angle on the front edges of the teeth in order to produce the proper "hook." The front edge of a ripsaw tooth should be straight up and down; and the front edge of a crosscut handsaw tooth should be about 15 deg from the vertical.
    Remember also to watch the small shiny surfaces left on the tooth points by jointing and to stop filing a tooth just as the shiny surface disappears.

14. After you have become reasonably proficient in filing a practice blade, sharpen a handsaw, which you may bring from home or which may be assigned you by the instructor.

15. Sharpen any other saws, such as bucksaws, pruning saws, log saws, or circular saws, about your home farm or about the shop that may need sharpening.

16. Inspect the forks, hoes, shovels, spades, rakes, etc., about your home or farm. If any need new handles, minor repairs, or sharpening, take them to the shop and put them in good condition.

8 ROPE WORK

1. Finishing the Ends of a Rope
2. Tying the Ends of Rope Together
3. Tying Loop Knots
4. Making Hitches
5. Shortening Rope
6. Splicing Rope
7. Making Rope Halters
8. Making Livestock Tackles
9. Using Blocks and Tackle
10. Taking Care of Rope

EVERY farmer has occasion to use rope, and it will be well worth his time to master some of the common knots, hitches, and splices. It is better to learn a few of the more useful ones thoroughly than to acquire only a general knowledge of many.

Rope work is not difficult, although it may at first appear to be. There is usually some system or order underlying the making of most knots, hitches, and splices, and once the system is understood, it is easy to make them. It is therefore important in studying a particular knot, hitch, or splice to learn the system or order involved.

1. FINISHING THE ENDS OF A ROPE

Relaying strands The ends of a rope frequently become untwisted, and the strands need relaying before the end is finished or an end knot or splice is made. The process of relaying strands is also frequently used in splicing rope.

To relay the strands of a rope, hold the rope in the left hand and with the right hand twist one strand tightly to the right and wrap it part way around the rope to the left (see Fig. 8-1). Then move the left thumb up the rope and hold the strand in place. In the same manner, twist and wrap the other two strands in turn, continuing

the process until the strands are relaid. It is best not to rotate the rope in the hand, but simply to move the hand straight up the rope to hold the various strands in place as they are relaid. With a little practice, strands can be relaid in practically as good condition as they were originally in the rope.

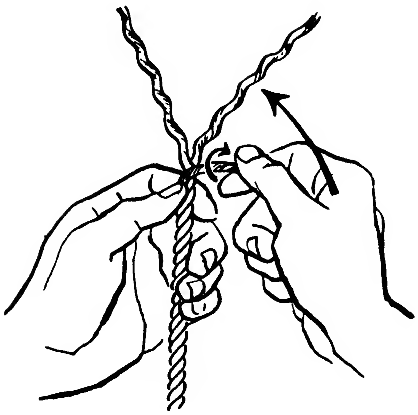


Fig. 8-1. Relaying strands. Each strand in turn is twisted to the right and then wrapped to the left and part way around the rope.

Whipping the ends of a rope Whipping is a neat and effective method of preventing the ends of a rope from untwisting and is recommended when the rope must be passed through small holes. When done with strong durable cord, like fish line, whipping is quite permanent. There are various ways of whipping a rope end. One of the best methods is as follows:

1. Unlay one strand of the rope back an inch or two from the end (see Fig. 8-2).

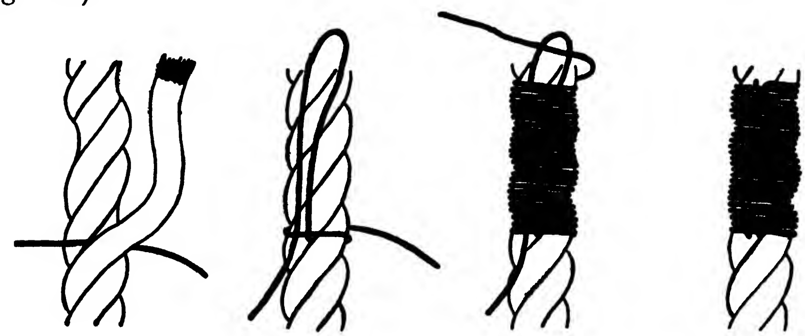


Fig. 8-2. Whipping an end of a rope is an effective way to prevent fraying.

2. Place one end of a strong cord, 2½ to 3 ft long, under the raised strand, leaving the short end of the cord 6 or 8 in. long; then relay the strand.
3. Hold the end of the rope up, letting the short end of the cord hang down.
4. Wrap the long end of the cord once around the rope, just above the short end.

5. Pull the short end of the cord toward the end of the rope and turn it back, forming a U, or a bight. It is best to lay the sides of this U in a groove in the rope.
6. Wind the long end of the cord around the rope and the U turn in the cord, keeping the turns tight and close together.
7. When the wrapping has progressed as far as desired, pass the long end of the cord through the end of the U loop in the cord, keeping it tight.
8. Pull on the short end of the cord, drawing the U loop back under the wrapping to about the center. Cut off the loose ends.

Making the crown knot This knot is used principally as the first step in making the crown splice. The steps are as follows:

1. Unlay the ends of the rope about five turns.
2. Bring strand 1 down between strands 2 and 3, forming a U loop (see Fig. 8-3).

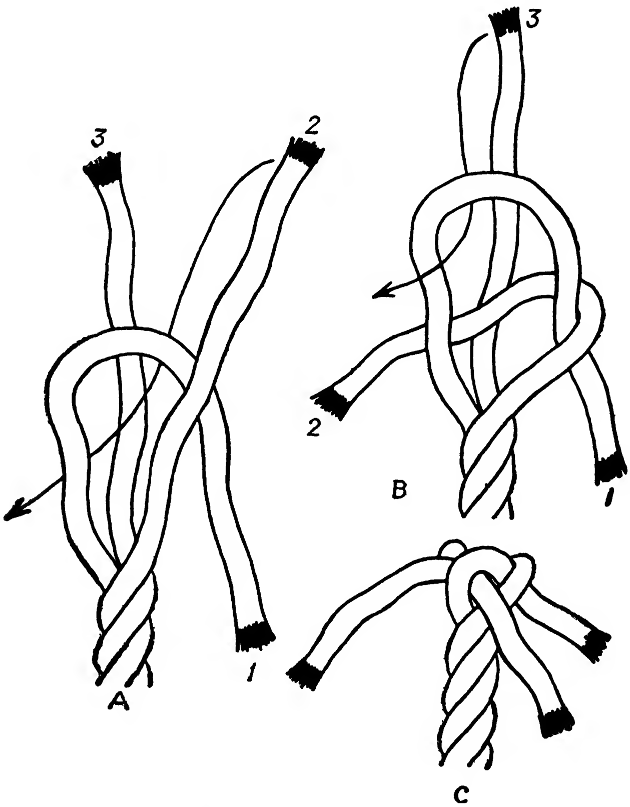


Fig. 8.3. The crown knot.

3. Place strand 2 around behind the U loop and in front of strand 3.
4. Pass strand 3 through the loop, and draw the strands down even and tight.

Making the crown or end splice This knot is one of the most useful and permanent end treatments for a rope. It is made by first making a crown knot and then proceeding as follows:

1. Place strand 1 over the first adjacent strand in the main part of the rope, and under the next strand (see Fig. 8-4).

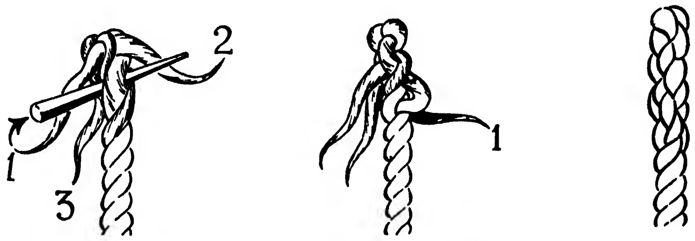


Fig. 8-4. The crown splice.

2. In a similar manner pass strand 2 over the strand in the main part that is adjacent to strand 2 and under the next.
3. Then pass strand 3 over the strand in the main rope that is adjacent to it and under the next. *Strand 3 should come out at the same place where strand 1 went in,* and when properly done, the three strands will come out of the main part equally spaced and no two in the same place.
4. Draw each of the strands up tight. It is a good plan to pull the end of each strand back up toward the end of the rope slightly. The strands, as they are tucked or woven into place, should keep almost at right angles to the strands of the main part and work diagonally around the rope, not straight down it.
5. Continue the process outlined in steps 1, 2, 3, and 4 until each strand is tucked under strands of the main rope three or four times.
6. When the strands have been woven far enough, the loose ends are cut off about ¼ in. long and the splice is smoothed by rolling it under the foot on the floor.

If it is desired to make a tapered splice, part of each strand may be cut out before taking the last one or two tucks.

Untwist the rope slightly to facilitate tucking In order to facilitate tucking in making the end splice, and other splices as well, it is a good plan to untwist the rope slightly. Hold the end of the rope between the palm and last three fingers of the left hand, leaving the thumb and first finger free (see Fig. 8-5). Untwist the rope slightly with a twist of the right hand. Then open up a place for the strand to be tucked, using the first finger of the left hand. Place the end of the

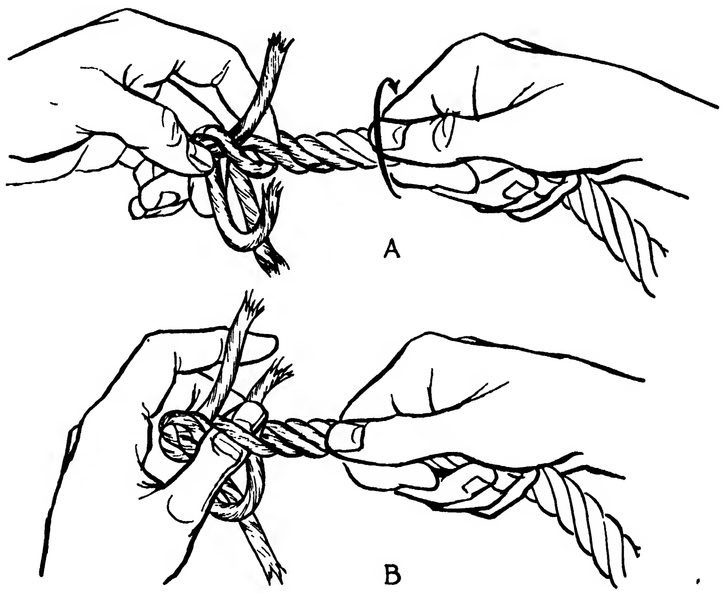


Fig. 8-5. An easy method of tucking. A. The rope is untwisted slightly and then the first finger of the left hand is placed under a strand, opening up a hole. *B.* As the finger is withdrawn, the thumb pushes the strand through the hole.

strand against the end of the first finger, and with the left thumb push it through the opening made for it. As the finger recedes out of the hole, the strand is thus made to follow it through.

Making the wall knot This is generally used as the first part of a Matthew Walker knot, although it is sometimes used alone as an end knot for a rope. To make the wall knot, proceed as follows:

1. Unlay the strands about 3 or 4 in. and hold the rope in the left hand, loose ends up.
2. Bring strand 1 halfway around and across in front of the rope, holding it in place with the left thumb (see Fig. 8-6).

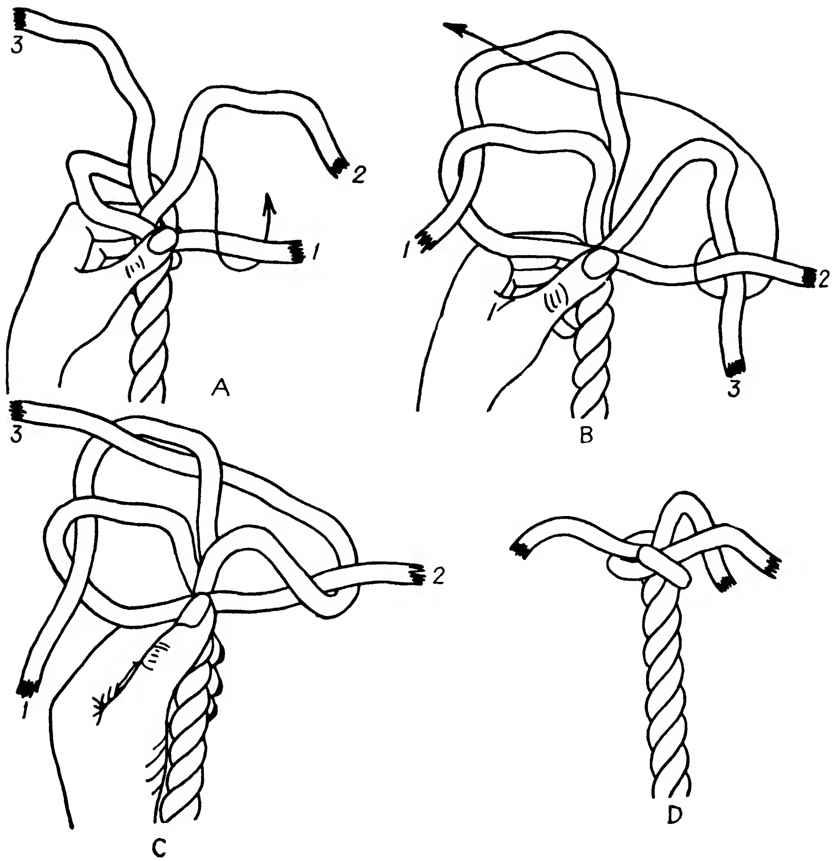


Fig. 8-6. The wall knot.

3. Pull strand 2 down and around the end of strand 1, releasing strand 1 from under the left thumb and placing the thumb on strand 2 to hold it in place temporarily.
4. In a similar manner, pull the end of strand 3 down and around the end of strand 2 and pass the end of strand 3 up through the loop of strand 1.
5. Draw the strands up even and tight.

Making the Matthew Walker knot This is one of the most useful and permanent end knots. It is made as follows:

1. First make a wall knot, but leave it loosely constructed (see Fig. 8-7).
2. Then pass end 1 up through loop *A* ahead of it, end 2 up through loop *B*, and end 3 up through loop *C*.

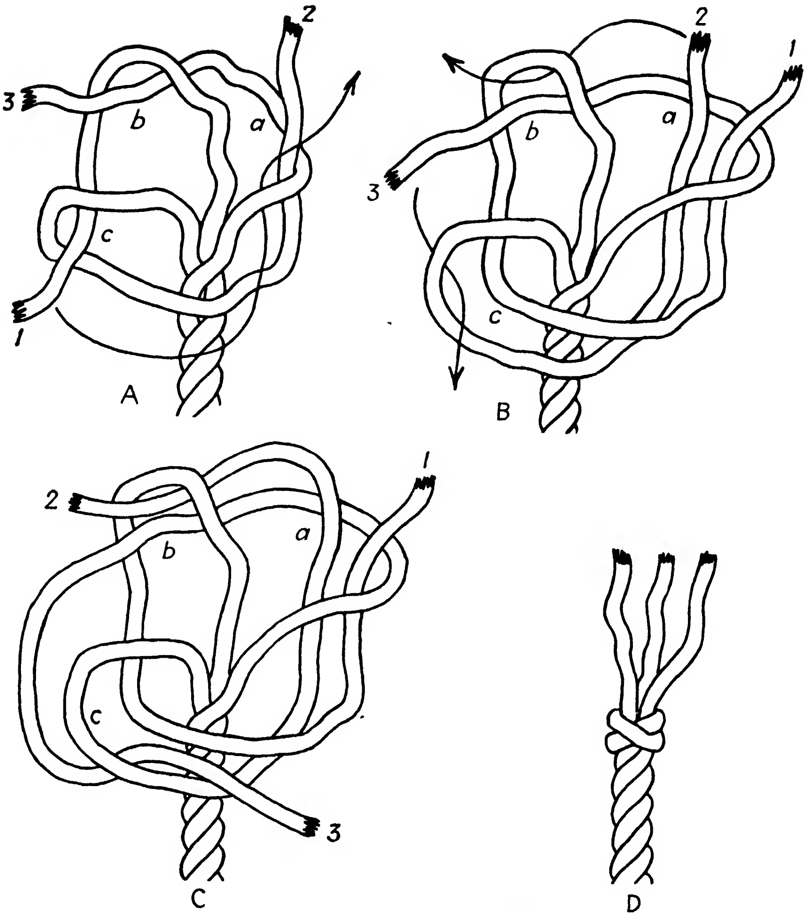


Fig. 8-7. The Matthew Walker knot.

3. Draw the strands up even and tight.

Making the Figure-8 knot Figure 8-8 shows the figure-8 knot, which may be used where a large bulky knot is needed on the end of a rope to keep it from drawing through a hole or through a pulley. It is easy to untie after pressure is released from it.

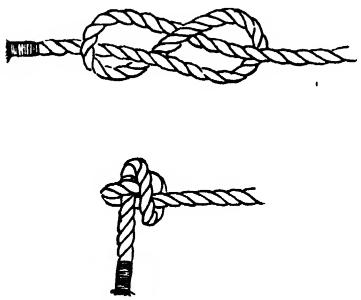


Fig. 8-8. The figure-8 knot.

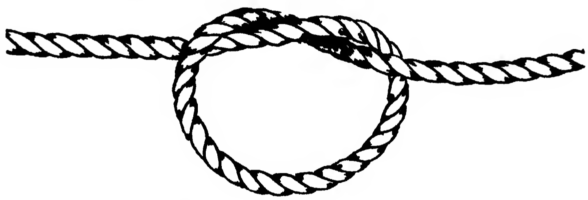


Fig. 8-9. The overhand knot.

Using the Overhand knot Figure 8-9 shows the overhand knot, which is sometimes used as an end knot in a rope, but more frequently as a step or a part of other knots or hitches. It is quickly and easily tied. As an end knot it is somewhat bulky, and after pressure has been applied, it may be difficult to untie.

2. TYING THE ENDS OF ROPE TOGETHER

Square knot Figure 8-10 shows the square knot, one of the most useful knots for joining the ends of twine, string, or rope. The following very simple rule may help in learning to tie the square knot:

Start the knot by crossing the ropes left over right. Then cross right over left. (Left over right, then right over left.)

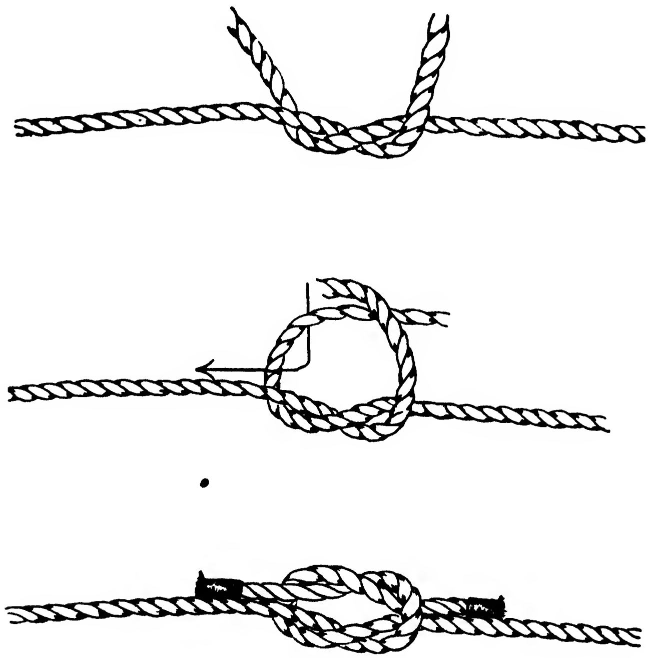


Fig. 8-10. The square knot is a very useful knot. Do not confuse it with the granny knot.

Granny knot Figure 8-11 shows the granny knot, which has much the same appearance as the square knot and is often mistakenly tied for the square knot. The granny knot will slip under strain and should normally not be used. It should be carefully studied so that it will not be tied when the square knot is desired.

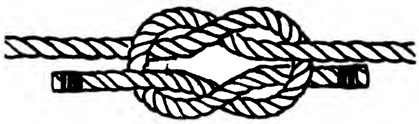


Fig. 8-11. The granny knot slips under load. It is often mistakenly tied instead of the square knot.

Fisherman's knot Figure 8-12 shows the fisherman's knot, used for joining silk lines or guts on fishing tackle. It may be used also for tying two ropes together. To make the fisherman's knot, place the two ends to be joined side by side. Then tie each end around the other, using an overhand knot.

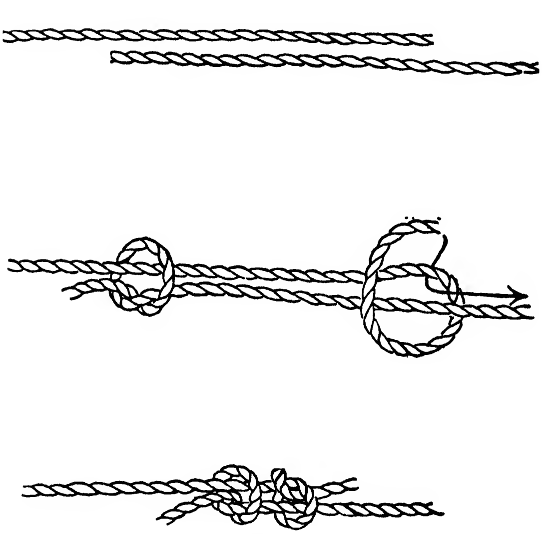


Fig. 8-12. The fisherman's knot.

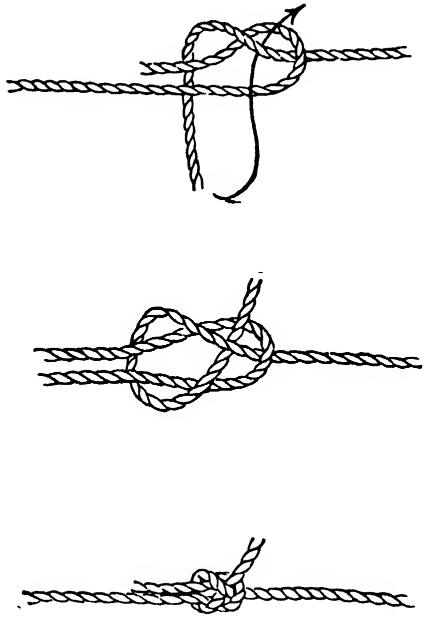


Fig. 8-13. The weaver's knot.

Weaver's knot The weaver's knot, also called the *sheet bend* or the *becket bend,* (Fig. 8-13) is good for joining two ropes, particularly ropes of different sizes. It remains secure without drawing up tight and is easy to untie.

3. TYING LOOP KNOTS

Slip knot Figure 8-14 shows the slip knot, which is used for tying a loop around an object. To tie a slip knot, make a U loop or

bight, and then tie the end around the main part of the rope, using an overhand knot.

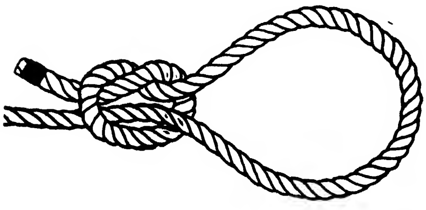


Fig. 8-14. The slip knot.

Bowline knot Figure 8-15 shows the bowline knot, one of the most useful of knots. It holds securely, yet will not slip or draw up tight. To make it, form a loop near the end of the rope, pass the end through the loop, around the main part of the rope, and back through the loop again.

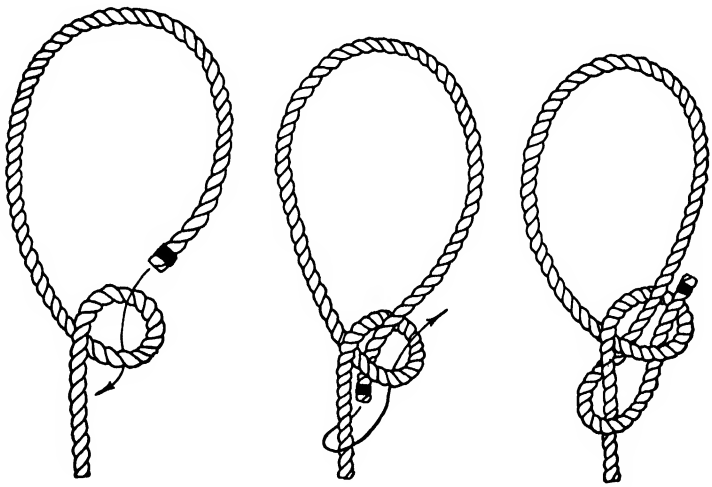


Fig. 8-15. The bowline knot.

Tomfool's, or double-bow, knot Figure 8-16 shows the tomfool's, or double-bow, knot. This is sometimes called a trick knot; however, it is very useful. It is often used for holding hogs while ringing them. The first loop is slipped over the hog's upper jaw, and the main part of the rope fastened to a post. The knot is untied, and the hog released, by simply pulling on the end that goes to the second bow or loop.

Hitching, or manger, knot Figure 8-17 shows the hitching, or manger, knot, commonly used for tying an animal to a hitching post or a manger. To make it, start as in tying a slip knot. Instead of

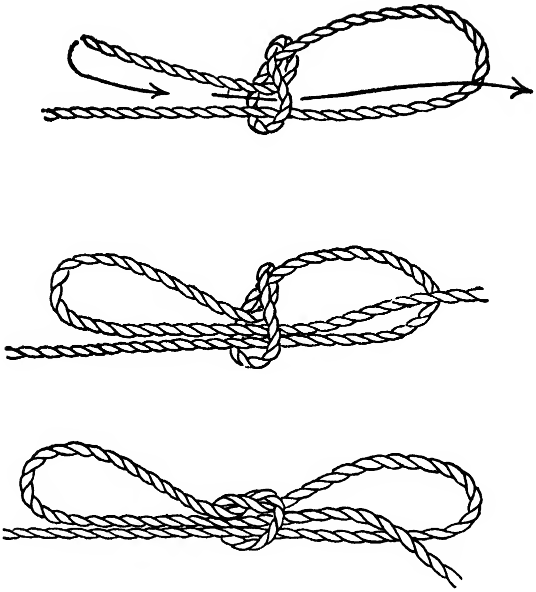


Fig. 8-16. The tomfool's, or double-bow, knot.

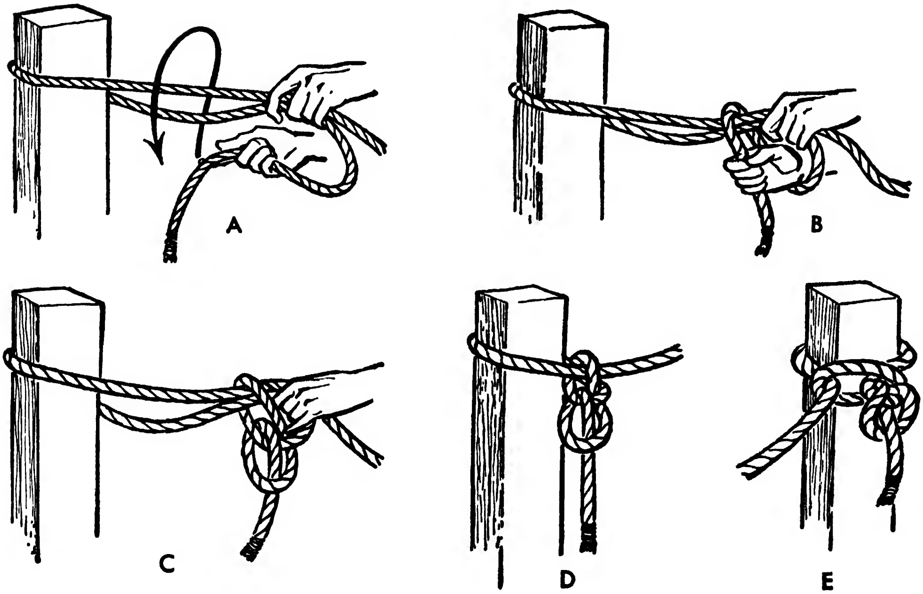


Fig. 8-17. The hitching, or manger, knot.

drawing the rope entirely through and completing the slip knot, however, leave a loop, and then pass the end of the rope through this loop.

Lariat knot Figure 8-18 shows the lariat knot. This knot is made as follows: Tie two overhand knots, one at the end of the rope and

drawn up tight, and the other back about a foot and drawn up loosely. Pass the end of the rope around the main part and through the loop as at *B*, and then again around the main part and through the loop as at *C*. Finish by drawing the parts up tight.

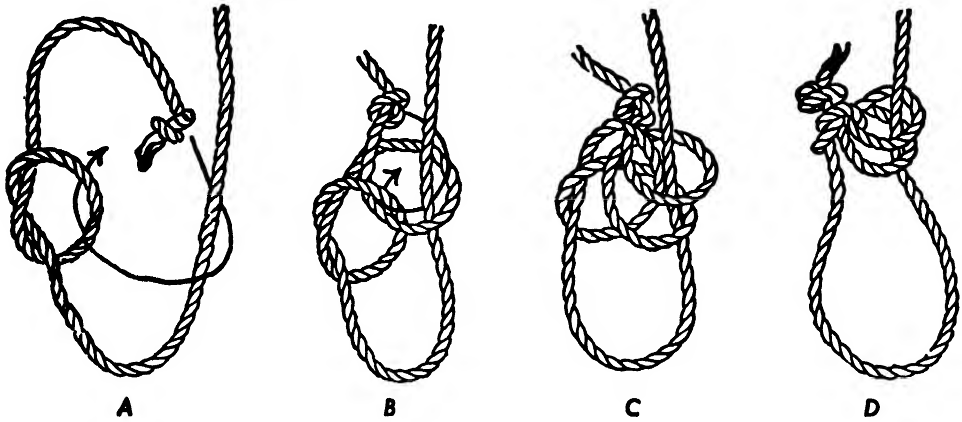


Fig. 8-18. The lariat knot.

Bowline on the bight Figure 8-19 shows the bowline on the bight, which is used for forming a loop in the middle of a rope or near the end where it has been doubled. It is tied as follows: Form a loop in the doubled rope and pass the doubled end of the rope through the loop, as at *B*. Then bring the doubled end down, and slip it over and back up around the loop.

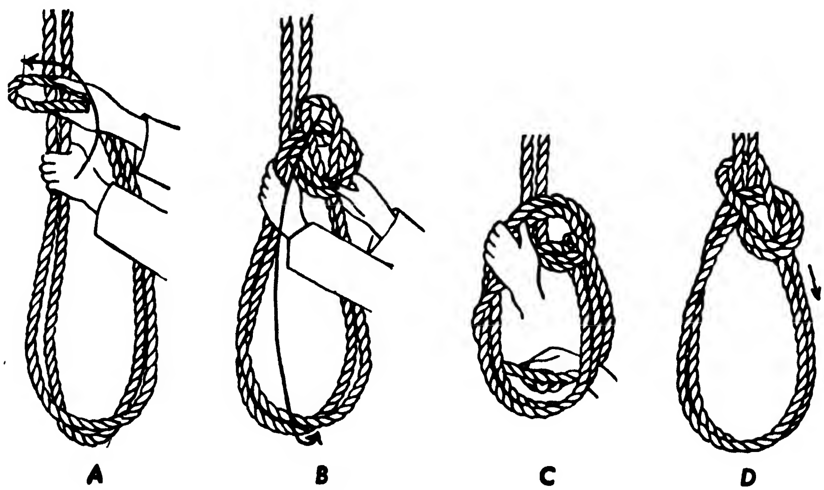


Fig. 8-19. The bowline on the bight.

4. MAKING HITCHES

Hitches are, in the main, quickly made temporary fastenings that depend upon the pull on the rope to keep them tight.

Half hitch Two forms of the half hitch are shown in Fig. 8-20. The half hitch is more often used in combination with other hitches, or as steps in making other hitches, than alone.

Timber hitch Figure 8-21*A* shows the timber hitch. This is similar to the half hitch but is made more secure by wrapping the loose end once or twice through the loop. The timber hitch and half hitch are often used in combination for holding or moving logs (see Fig. 8-21*B*).

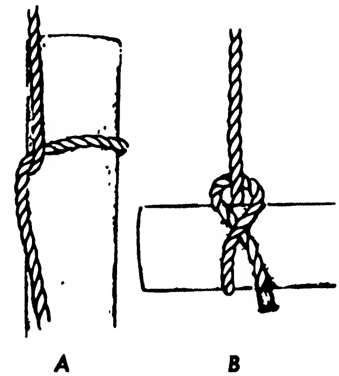


Fig. 8-20. Two forms of the half hitch.

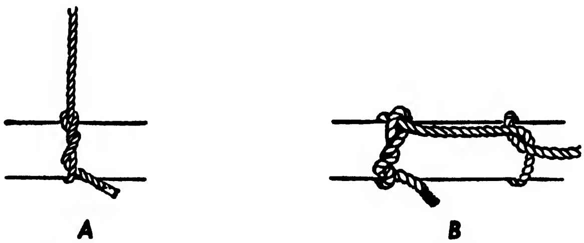


Fig. 8-21. *A*, the timber hitch, *B*, the timberhitch and half hitch combined.

Clove hitch One of the most useful ways of fastening a rope to a post or stake is the clove hitch. Two methods of making the hitch are illustrated in Fig 8-22.

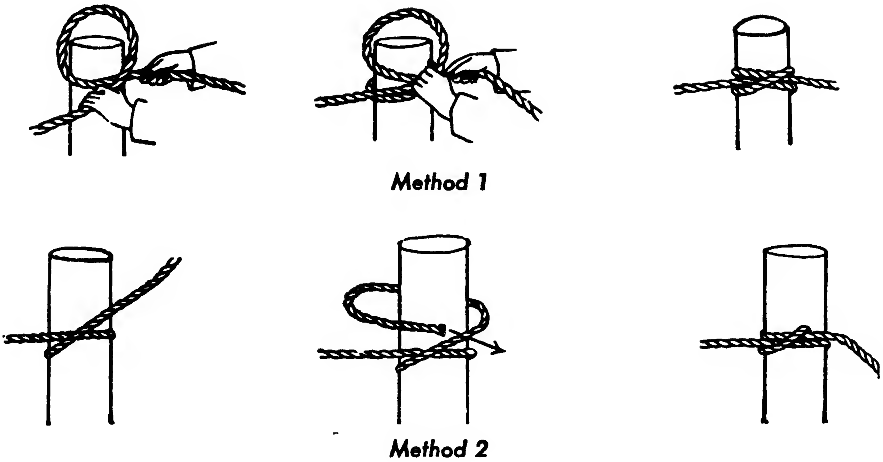


Fig. 8-22. The clove hitch.

Miller's, or grain-sack, knot Figure 8-23 shows the Miller's, or grain-sack, knot, by far the best knot for tying grain sacks. It is a very useful knot, particularly for farmers. To tie the knot, place the string

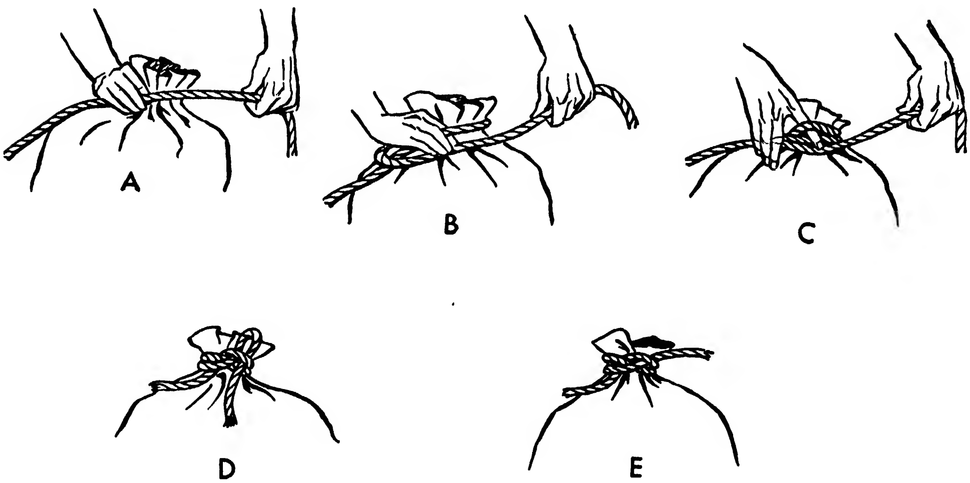
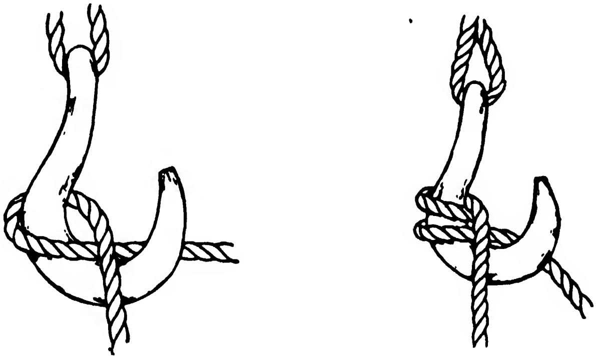


Fig. 8-23. The miller's, or grain-sack, knot.

across the front of the neck of the bag, under the last three fingers but over the first finger of the right hand, as at *A*. Take the string around the neck of the sack, under the heel of the right hand and under all fingers, but over the end of the string, as at *B*. Wrap the string around the neck of the sack a second time in the same manner. Then with the first finger of the right hand, pull the end of the string up

under the loop formed when the knot was started (see Fig. 8-23*C*). Leave the loop as shown at *D,* or draw it on through as shown at *E,* depending upon how securely the sack is to be tied. If the loop is left as at *D,* the knot is ordinarily secure enough and yet it can be untied easily by pulling on the end of the string. For long shipments or rough handling, the knot should be completely formed as at *E.*

Blackwall hitch Figure 8-24 shows the Blackwall hitch, used for fastening a rope temporarily to a hook.



A B

Fig. 8-24. Two forms of the Blackwall hitch.

Cat's paw Figure 8-25 shows the cat's paw, which is also used for fastening a rope to a hook. It may be used in the middle of a rope

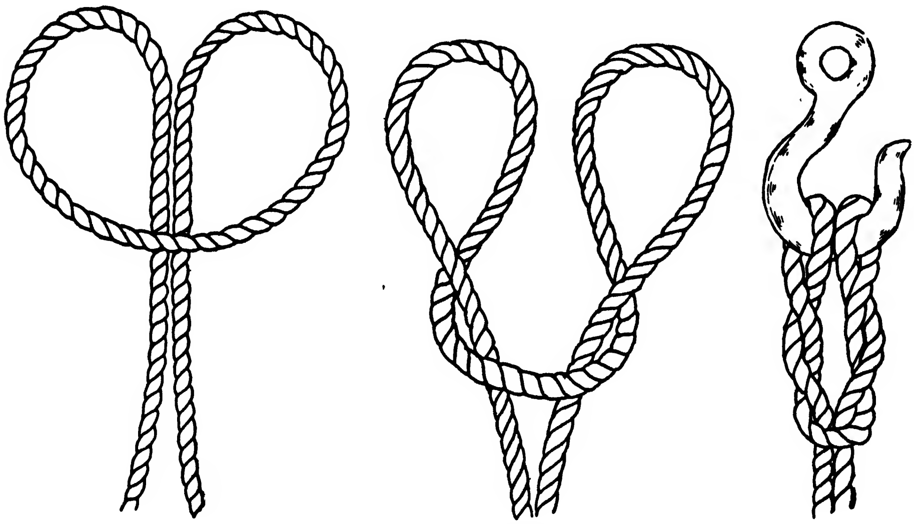


Fig. 8-25. The cat's-paw.

as well as near a free end. Pull may be applied to either or both ends. It is quickly made and detached.

Scaffold hitch The scaffold hitch may be made by wrapping the rope around a board as shown at *A*, *B*, and *C*, Fig. 8-26, and then fastening the end to the main part of the rope with a bowline as shown at *D*.

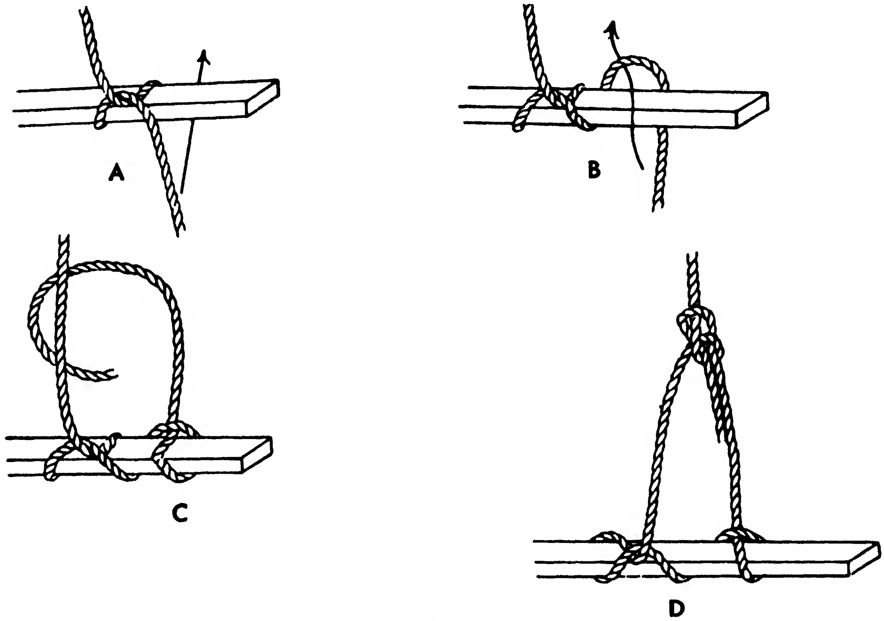


Fig. 8-26. The scaffold hitch.

Snubbing, or running, hitch Figure 8-27 shows the snubbing, or running, hitch. This is used for snubbing animals or pulling in a rope against a force and fastening it to prevent it from being pulled out again. If a pull comes on the rope, the hitch will not slip; but while

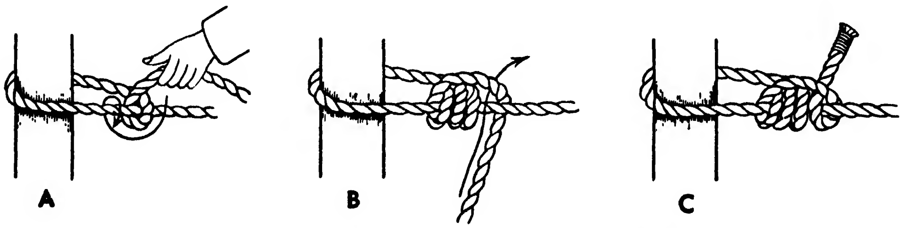


Fig. 8-27. The snubbing, or running, hitch.

the rope is held between the hitch and post with one hand, the hitch can very easily be slipped out away from the post with the other.

Well-pipe hitch Figure 8-28 shows the well-pipe hitch, which is useful for securely fastening a rope to a pipe or other cylindrical object. It may be made as follows: Wrap the rope around the pipe, making a half hitch, as at *A*. Make a second wrap, wrapping downward and over the main part of the rope, as at *B*. Then make a third wrap, this time going under the main part of the rope and up between the last two turns, as at *C* and *D*. Complete the hitch by making a clove hitch in the end of the rope. Pull on the rope should be parallel with the pipe.

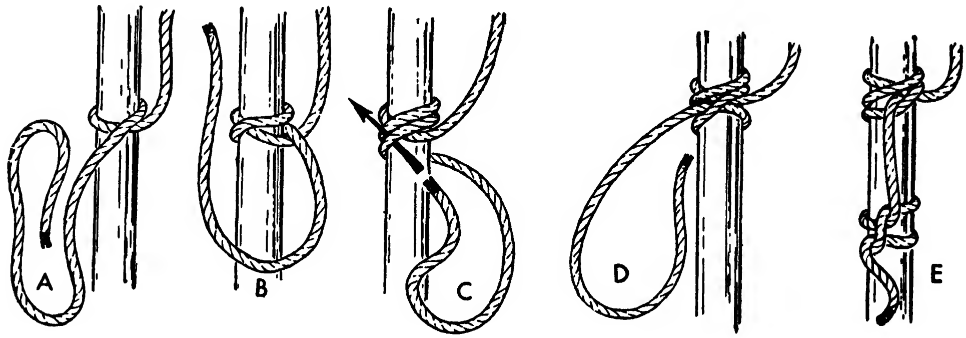


Fig. 8-28. The well-pipe hitch.

5. SHORTENING ROPE

Sheepshank Figure 8-29 shows the sheepshank, which is useful for shortening a rope temporarily. To make the sheepshank, gather up the rope, forming two loops of the desired length, as at *A*. Then make

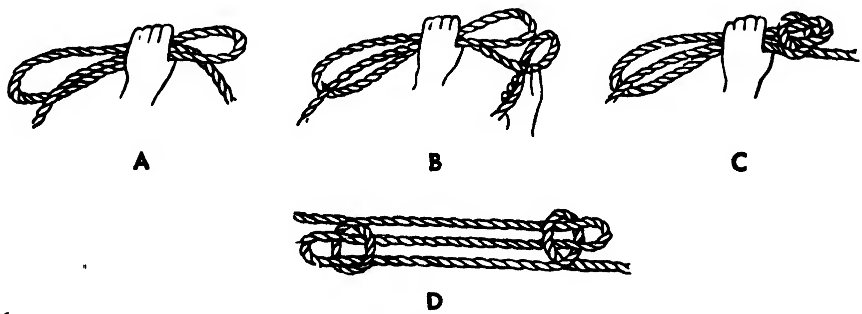


Fig. 8-29. The sheepshank.

a half hitch around the end of each loop as at *B* and *C*. If tension is kept on the rope, the sheepshank will remain secure. If the tension is not steady, and yet it is desired to keep the sheepshank, then the ends of the rope may be threaded through the ends of the loops.

6. SPLICING ROPE

Short splice The short splice is made where a considerable enlargement in the rope would not be objectionable or where only a short length of rope can be spared for making the splice. It may be made as follows:

1. Unlay the strands for six or seven turns on the ends to be joined.
2. Place the two ends together so that the strands from one end alternate with the strands from the other. Be sure that every strand branches outward from the main rope directly and without crossing over the center of the rope (see Fig. 8-30).

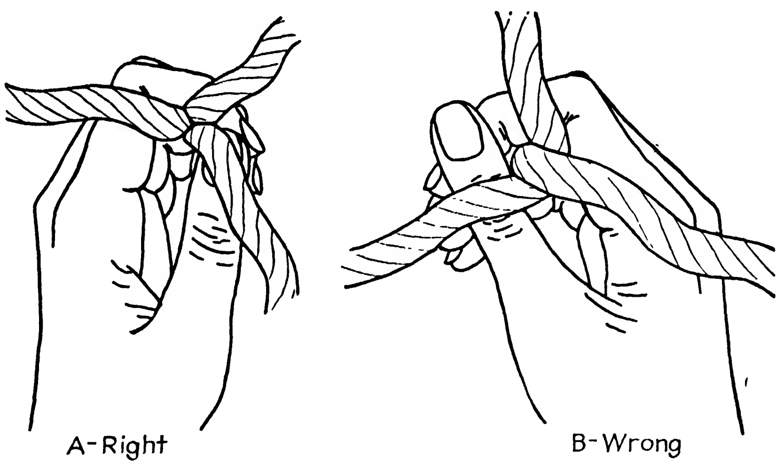


Fig. 8-30. Strands spread out preparatory to placing two ropes together for splicing.

3. Tie each strand from one rope with the corresponding strand from the other rope, using a simple overhand knot. When all three strands are thus tied, draw them all up even and tight (see Fig. 8-31, *B* and *C*).
4. Tuck the strands from each rope under the strands of the other, using the method outlined for the crown or end splice (Fig. 8-4, page 264). Tuck the strands alternately, making a single tuck on

one strand, then a single tuck on the next strand, etc. Each strand should ultimately be tucked three or four times.

If a tapered splice is desired, part of each strand may be cut out before taking the last few tucks. To facilitate tucking, use the method of partly untwisting the rope as illustrated in Fig. 8-5. The strands, as they are tucked or woven into place, should keep almost at right angles to the strands of the main rope and work diagonally around the

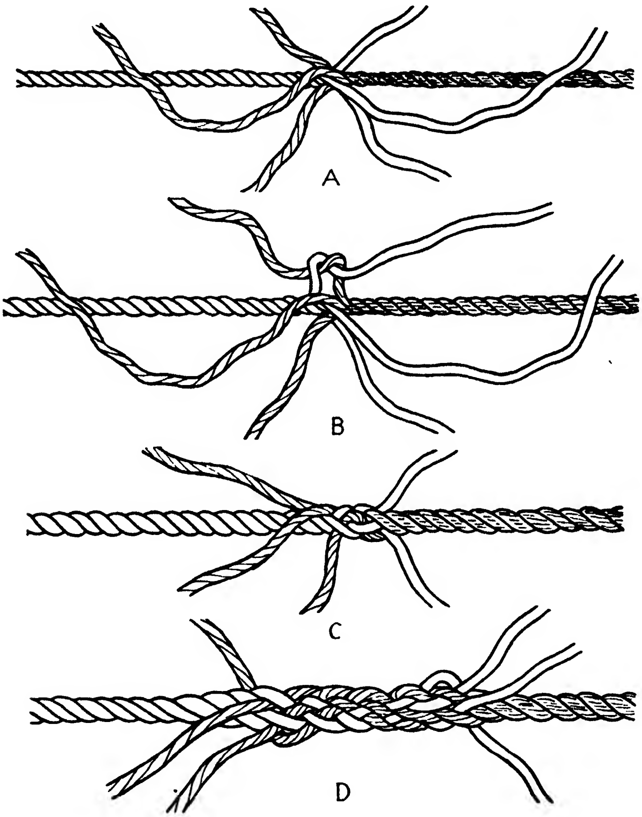


Fig. 8-31. The short splice.

rope, not straight down it. To make a firm, tight splice, it is a good plan to keep the strands drawn up tight as they are tucked, and to pull the ends of the strands back toward the middle of the splice occasionally as the work proceeds.

Long splices Figure 8-32 shows a long splice. This splice should be made if the rope is to pass through pulleys or if a neat splice is desired

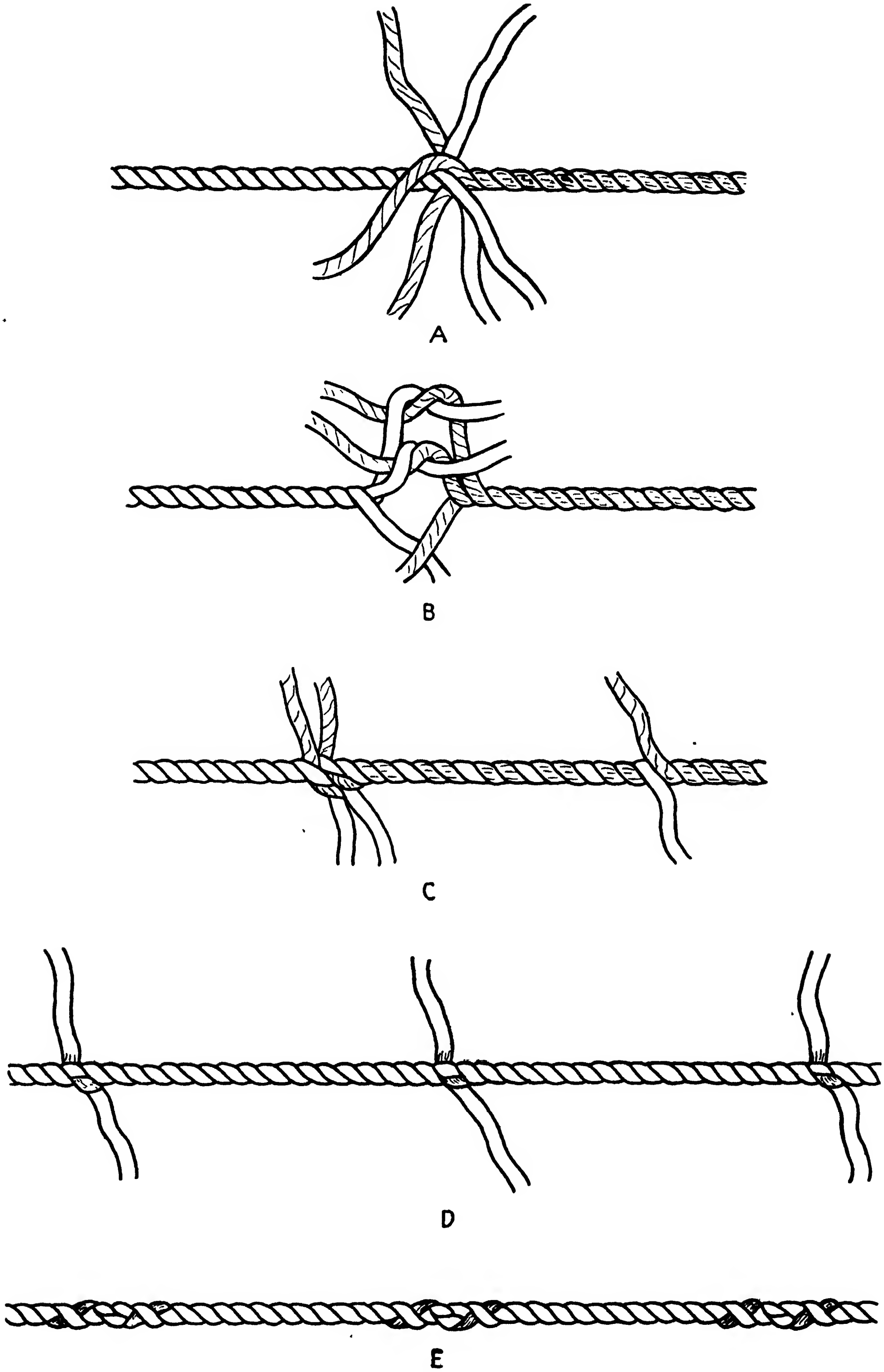
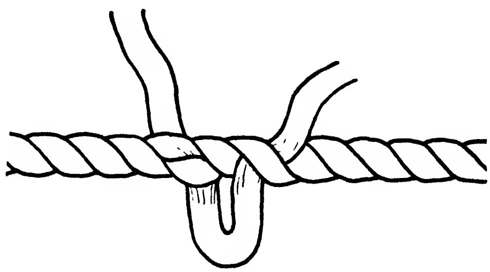


Fig. 8-32. The long splice.

that will not appreciably increase the size of the rope. The following directions are for making the long splice in a three-strand rope. Four-strand ropes are spliced in a similar manner.

1. Unlay the strands of each rope about fifteen turns.
2. Place the two ends tightly together in exactly the same manner as for the short splice (see Fig. 8-32*A*). Be sure that the strands from one end alternate with the strands from the other end.
3. Tie overhand knots in two pairs of the strands (Fig. 8-32*B*). Draw the knots up tight. Be careful that the strands are properly paired.
4. Unlay one strand of the pair not tied, and lay the other strand in its place, twisting it tightly as it is laid (see Fig. 8-32*C*). When all but about 6 in. of the strand is laid, tie the two strands, using a simple overhand knot (see Fig. 8-9).
5. Turn the rope end for end, and untie either pair of strands that were tied at the beginning of the splice. Unlay the strand that comes from the right and lay the other strand in its place. When all but about 6 in. of the strand is laid, tie the two strands, using a simple overhand knot. The splice will then appear as in Fig. 8-32*D*.
6. Cut off all strands to about 6 in. long, and weave or tuck each one into the rope, using the same general method of tucking as used in the crown or end splice and in the short splice. Each strand should go over the first adjacent strand of the main rope and under the next (see Fig. 8-33). Take at least three such tucks with each strand. Then cut off the strands, leaving the ends about ¼ in. long.

Fig. 8-33. Tying and tucking the ends in finishing the long splice. After tying, each strand is placed over the first strand of the main rope and under the next. In a similar manner, each strand is tucked at least twice more, making three tucks in all.



Repairing a broken strand To repair a rope with one broken strand, unlay the broken strand five or six turns each way from the break, and then lay in its place a good strand from a rope of the same size, or from the end of the rope being repaired. Join the ends of the new strand to the ends of the broken strand and tuck them in the same manner as in the long splice.

Eye splice The eye splice is used in many places where a permanent loop is to be made in the end of a rope. It is made as follows:

1. Unlay the strands about five turns.
2. Double the end of the rope back, forming a loop of the desired size, and place the unlaid strands as shown in Fig. 8-34*A*.
3. Place strand 1 under a strand of the main rope (see Fig. 8-34*B*).

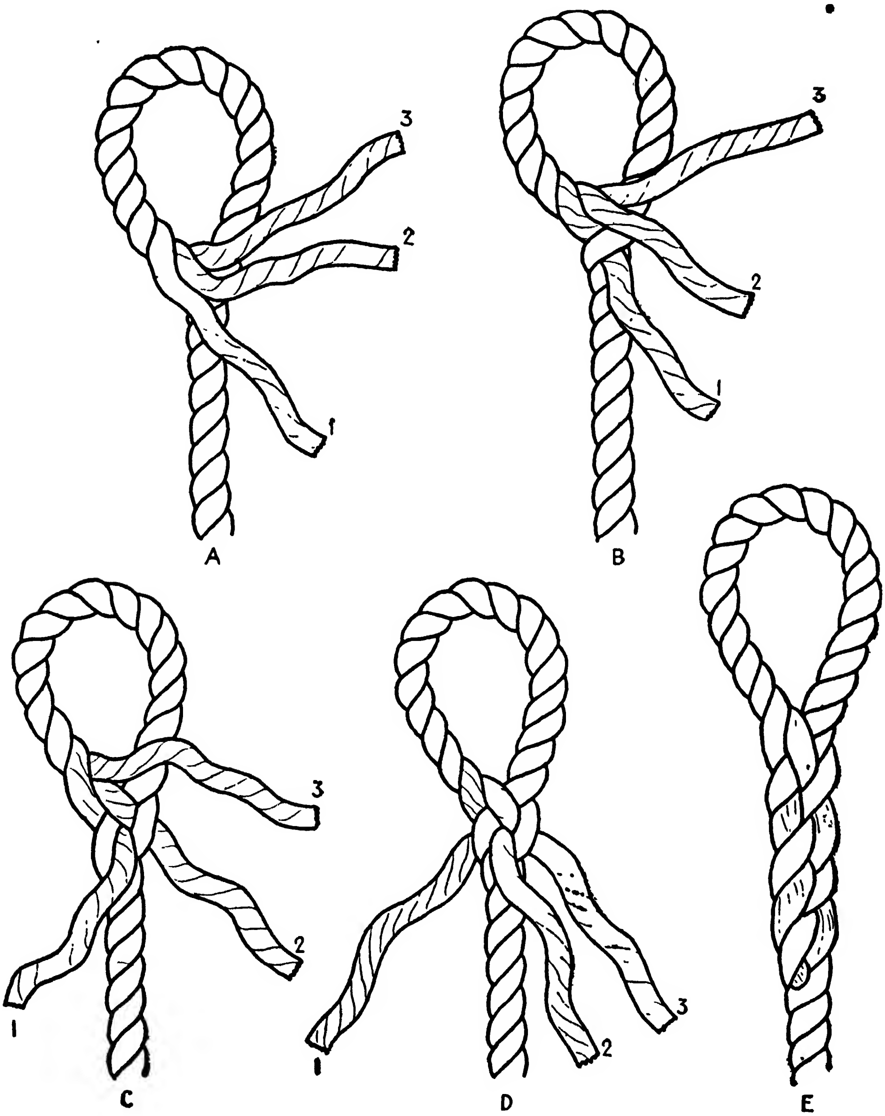


Fig. 8-34. The eye splice.

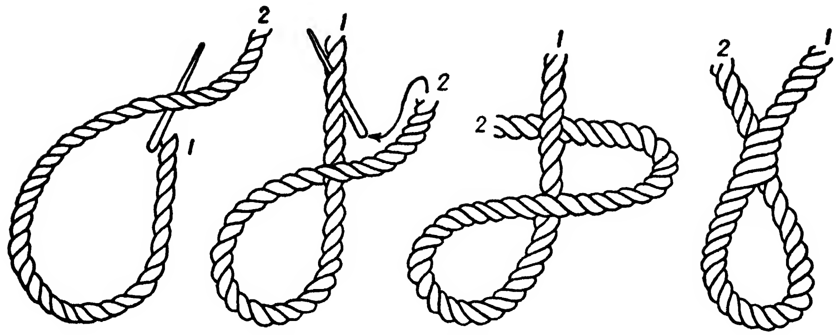


Fig. 8-35. The loop splice.

4. Place strand 2 over the strand under which 1 was placed, and under the next (see Fig. 8-34*C*).
5. Place strand 3 over the strand under which 2 was placed, and under the next. Strand 3 must come out of the rope at the same point where strand 1 went in (see Fig. 8-34*D*). (*This is important.*)
6. Continue weaving and tucking the strands as in the crown splice and the short splice.

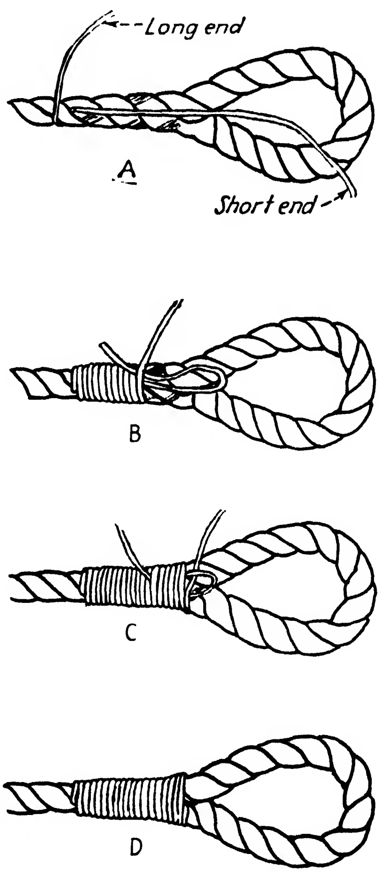


Fig. 8-36. Serving an eye splice.

A modification of the eye splice, called the *side splice*, is used in splicing the end of one rope into another rope at a point other than its end.

Loop splice The loop splice is used for making a loop or eye in a rope at a point other than the end. It is made as follows:

1. Raise two strands of part 2, and pass part 1 through (see Fig. 8-35).
2. Raise two strands in part 1, *at a point that will give the desired size of finished loop,* and pass part 2 through.
3. Draw up tight.

Serving a splice Splices are sometimes served or wrapped tightly with a strong cord. This keeps the ends of tucked strands from pulling out, gives the splice a neater and more finished appearance, and makes it more durable. In cases where the length to be served is not great, or where the serving is near the end of the rope, it may be done in exactly the same manner as whipping, as explained on page 262. Where serving must be placed at some distance from the end of the rope, however, or where several inches are to be served, then a similar method, described below and illustrated in Fig. 8-36, may be used.

1. Raise one strand of the rope, and pass the cord under it.
2. Lay the short end of the cord along the rope in the direction of the serving.
3. Wrap the long end of the cord tightly and snugly around the part to be served and over the short end of the cord.
4. When the serving is almost completed, lay the short end of the cord back, forming a loop (see Fig. 8-36*B*).
5. Wrap six or eight turns more with the long end of the cord, and place the end through the loop (see Fig. 8-36*C*).
6. Draw the short end of the cord up tight, and cut off the exposed ends.

7. MAKING ROPE HALTERS

Making the nonadjustable halter Figure 8-37 shows a nonadjustable halter. It is quickly and easily made, only a loop splice, a side splice, and an end splice being required. The lengths of the various parts of the halter are given in Table 8-1.

TABLE 8-1. Approximate Dimensions for Rope Halters

Kind of halter	Diameter of rope, in.	Total length of rope, ft	Length of parts, in.	
			Nosepiece	Headpiece
Horse	1/2 or 5/8	14	8	16
Cow	1/2	12	7	14

Making the adjustable halter Figure 8-38 shows an adjustable halter. It is likewise simple and easily made. A loop splice, an eye splice, and an end splice are the only splices required. It is a good plan to make both the loop splice and the eye splice quite small, so that the halter

will not be easily worked out of adjustment as the animal moves its head about.

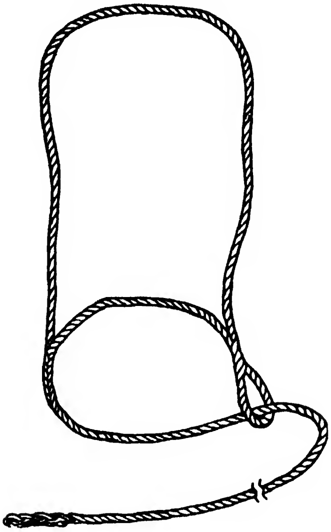


Fig. 8-37. A nonadjustable halter.

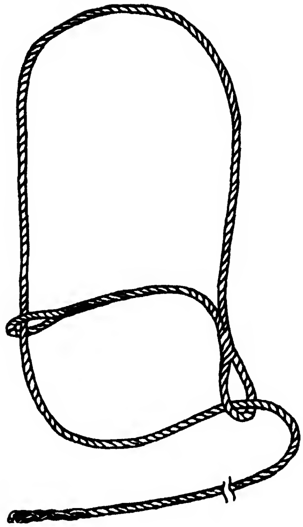


Fig. 8-38. An adjustable halter.

Making the nonadjustable halter with guard loop Figure 8-39 shows a nonadjustable halter with a guard loop. This is a good type of permanent halter. The guard loop prevents the halter from loosening or tightening beyond a certain amount. After the first side splice is made

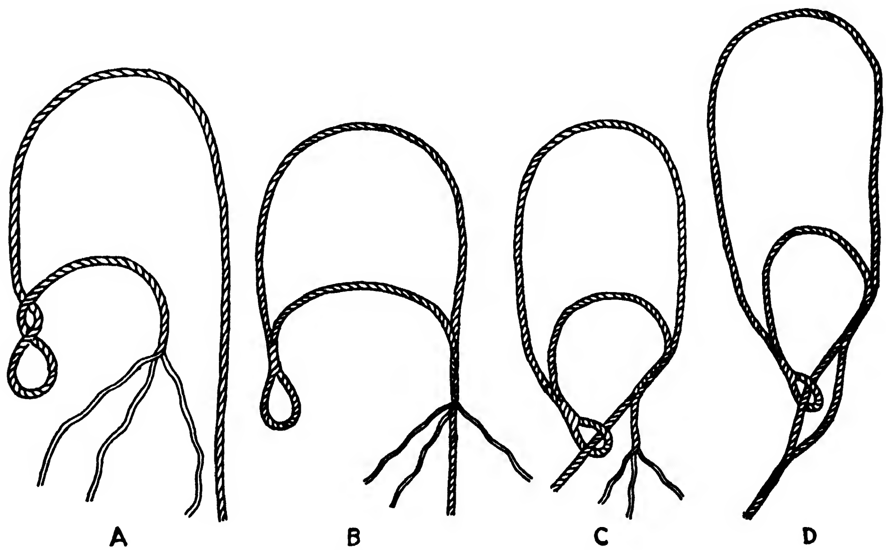


Fig. 8-39. A nonadjustable halter with guard loop.

(Fig. 8-39*B*), relay the strands for a distance of 5 or 6 in., and then make the final side splice.

Making a calf halter The calf halter, popular with calf-club members, is illustrated in Fig. 8-40. To make it, first make a loop splice, and then fasten the end of the headpiece to the main rope with a special tight-fitting, adjustable loop. To make this special loop unlay the strands back about 7 in. from the end. Then wrap them around the main rope as shown in Fig. 8-41, and weave them back into the head piece in the same manner as in an end splice or a side splice.

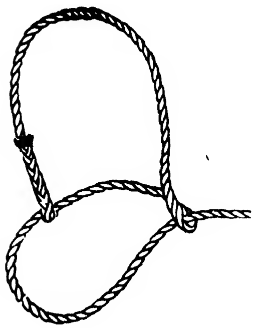


Fig. 8-40. A calf halter.

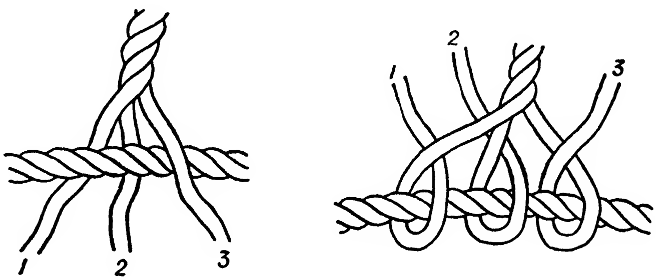


Fig. 8-41. Detail of halter splice used on calf halter.

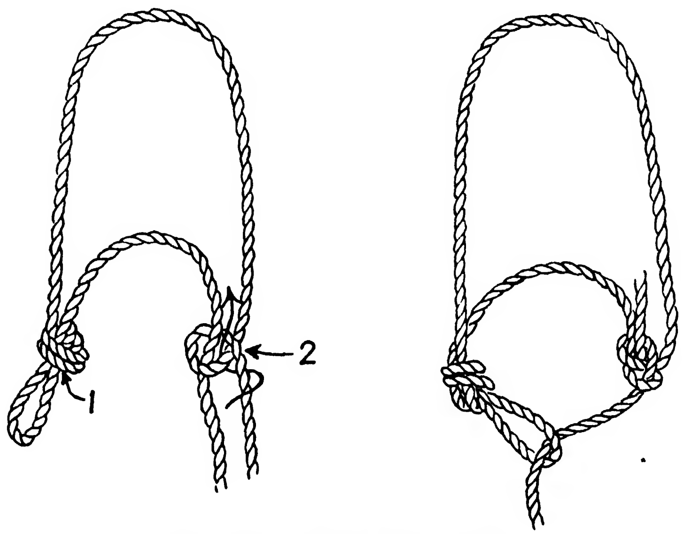


Fig. 8-42. An emergency halter.

Making an emergency, or temporary, halter A halter for emergency or temporary use is easily and quickly made as illustrated in Fig. 8-42. To make it, turn the end of the rope back upon itself, forming a loop.

Then tie an overhand knot in the doubled part, as at 1, Fig. 8-42. Next tie the end of the nose piece to the main part with bowline, as at 2.

8. MAKING LIVESTOCK TACKLES

Making the leading or tying tackle The tackle illustrated in Fig. 8-43 is effective in breaking a colt to lead. It is also good for breaking horses of pulling back when tied. Make the loop around the body so that it will loosen promptly when the tie rope is slackened. In case the manger or hitching rack is low, run the tie rope through a loop or strap in the halter ring, as at *A,* Fig. 8-43, instead of through the halter ring itself.

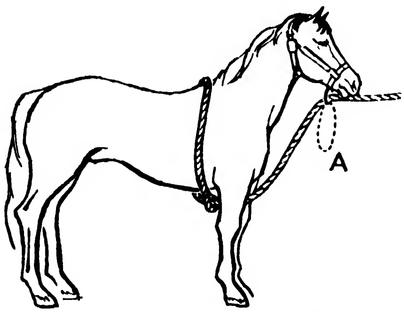


Fig. 8-43. A leading or tying tackle.

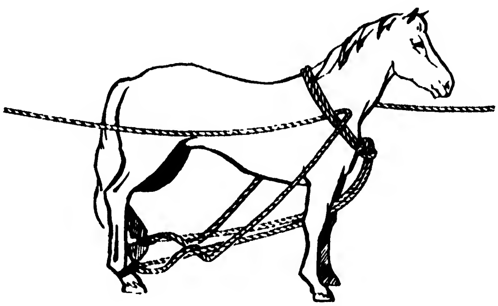


Fig. 8-44. A casting tackle for horses.

Making casting tackle for horses. The tackle illustrated in Fig. 8-44 is recommended for throwing horses with safety to both the animal and the workman. To make the tackle, tie a bowline on the bight (see page 272) and place it over the animal's head, fitting it much like a horse collar. Then run the ends of the rope between the front legs to rings in ankle bands on the hind feet. After it has passed through the rings, wrap each rope once around itself and pass it under the doubled rope around the neck, extending the rope on one side to the rear and the rope on the other side to the front. To throw the animal, back him and tighten the ropes at the same time.

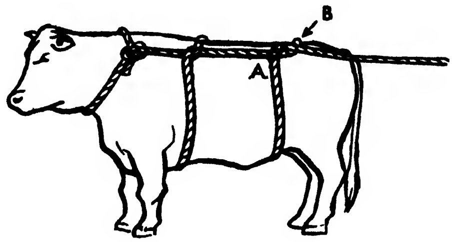


Fig. 8-45. A casting tackle for cattle.

Making casting tackle for cattle A simple casting tackle for cattle is illustrated in Fig. 8-45. To make the tackle, tie the rope around the

animal's neck by means of a bowline. Then make two half hitches, one at the front of the body and the other at the rear. The rope should come in front of the hipbone at *A*, Fig. 8-45, and behind the other hipbone at *B*. To throw the animals, pull backward and toward the side on which it is to be thrown.

9. USING BLOCKS AND TACKLE

A *block* is a case or shell containing a sheave or grooved pulley, or a set of them, over which rope is run (see Fig. 8-46). A block with one

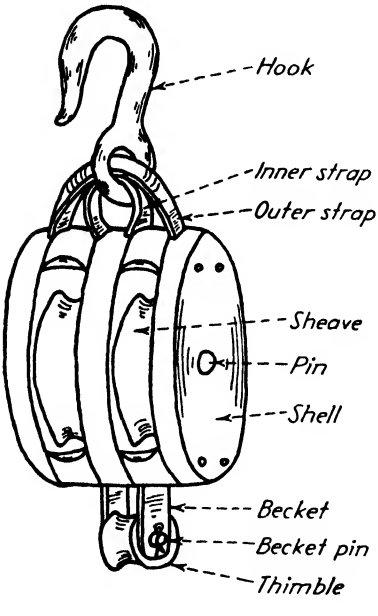


Fig. 8-46. Parts of a block.

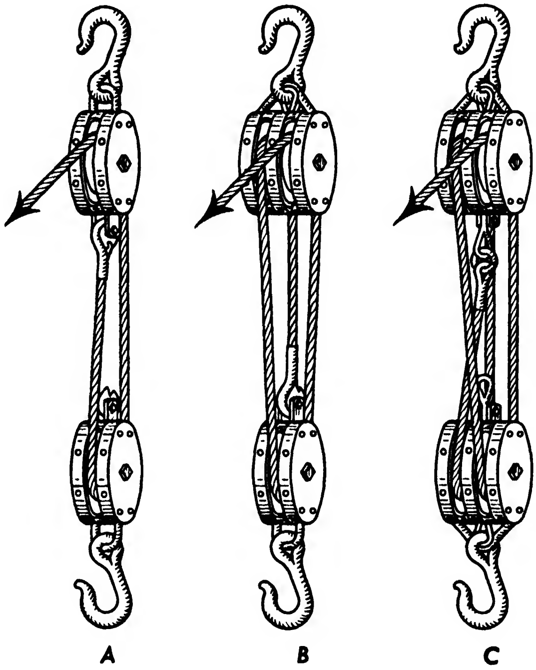


Fig. 8-47. Simple tackles. The mechanical advantage of tackle *A* is 2, that of tackle *B* is 3, and that of tackle C is 4. Note the number of plies of rope supporting the movable block in each case.

sheave is called a single block, one with two sheaves a double block, one with three sheaves a triple block, and so forth. A *tackle* is a set of blocks and rope for raising, lowering, or moving heavy loads (see Fig. 8-47).

The mechanical advantage of a tackle is equal to the number of plies of rope passing to and from the moving, or load, block. Thus

the mechanical advantage of tackle *A* (Fig. 8-47) is 2, that of tackle *B* is 3, and that of tackle *C* is 4. In other words, neglecting friction losses, a pull of 50 lb. on the fall rope, that is, the free end of the rope, of tackle *A* would lift a load of 100 lb, while the same pull on the fall ropes of tackles *B* and *C* would lift loads of 150 and 200 lb, respectively.

In moving a load with a tackle, the end of the fall rope always moves farther than the load itself, the movement of the two being expressed as a formula as follows:

$$\text{travel of fall rope} = \text{travel of load} \times \text{mechanical advantage}$$

It is evident, therefore, that in using blocks and tackle, increase in force or pull is gained at the expense of movement. In other words, a tackle enables a small force, by moving a greater distance, to lift or move a heavier load a short distance.

Using blocks and tackle with safety Care should always be used in moving heavy objects. Some of the more important precautions to be observed in using blocks and tackle are as follows:

1. Always fasten tackle securely.
2. Never stand where you could be hurt in the event of accidental loosening or breaking of some support or fastening.
3. Never straddle or stand near a rope that is being paid out or drawn in under tension.
4. Wear gloves to prevent burns or abrasion of the skin by sharp ends of rope fibers.
5. Keep hands and clothing away from moving ropes or pulleys.
6. Avoid the use of faulty equipment, such as a block with a hook that has started to straighten or a block with bent, broken, or cracked shell.

Reeving a set of blocks By reeving a set of blocks is meant passing the rope through the blocks to form a tackle. The procedure for reeving a set of blocks is usually obvious. A good way is to place the two blocks reasonably close to each other, and then pass the end of the rope backward through the blocks, opposite to the direction the rope will move when the tackle is used in lifting a load (see Fig. 8-48). Finish by attaching the end of the rope to the becket (the ring or fastening on the block opposite the hook), preferably with an eye splice or the block becket bend, as illustrated in Fig. 8-49.

Block becket bend Figure 8-49 shows the block becket bend, used for temporarily fastening the end of a rope to a block. It is in reality a form of clove hitch. To make the block becket bend, pass the rope through the becket (see Fig. 8-49*A*), and then take a turn around the

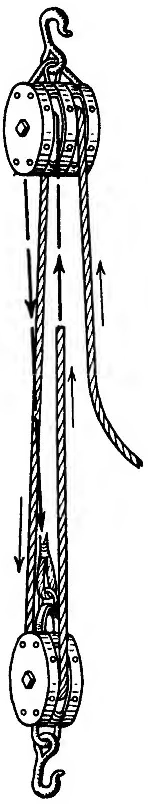


Fig. 8-48. To reeve a set of blocks, pass the rope backward through the blocks opposite to the direction it will move when lifting a load.

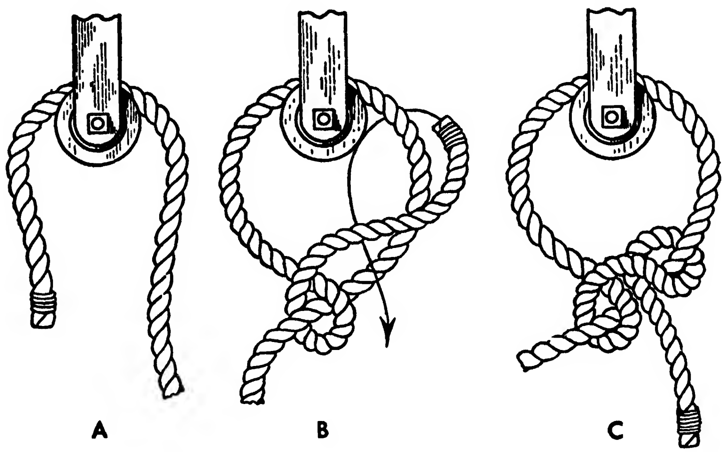


Fig. 8-49. The block becket bend.

main rope outside the loop (Fig. 8-49*B*). Next make a turn around the main rope and through the loop, thus completing a clove hitch.

10. TAKING CARE OF ROPE

Coiling and uncoiling a rope Rope should be coiled in a clockwise direction so as to untwist the strands and prevent kinking. It may be coiled on the ground or floor, winding clockwise (see Fig. 8-50), or in a loose coil around the flexed left forearm, winding between the thumb and fingers of the open hand and around the elbow (see Fig. 8-51).

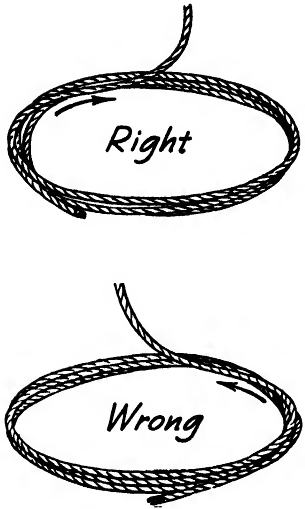


Fig. 8-50. Right and wrong methods of coiling a rope. To prevent kinking and tangling, the rope should be coiled in a clockwise direction and should be uncoiled in a counterclockwise direction.

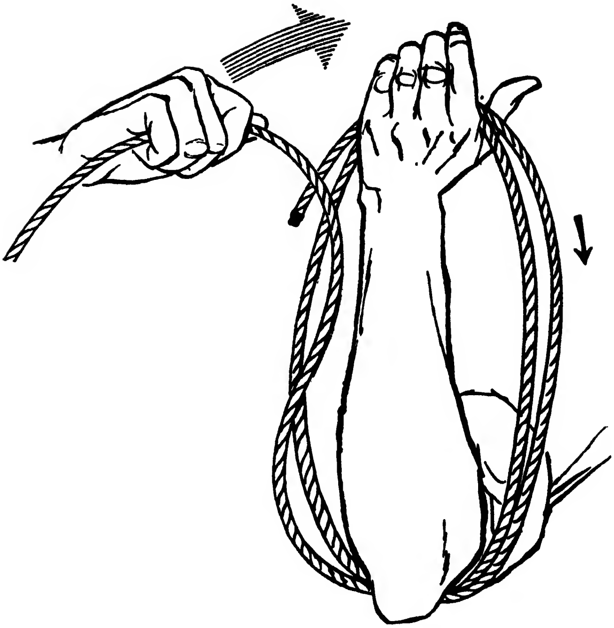


Fig. 8-51. A good way to coil a small rope is to wrap it loosely around the flexed left forearm in a clockwise direction.

To take a rope out of a coil, unwind it in a counterclockwise direction. If it starts to uncoil in a clockwise direction, turn the coil over and pull the end of the rope up through the center from the other side. Kinking as a rope is taken from a coil is an indication that it is being pulled from the wrong side of the coil.

The following method is a good one for keeping rope that is reeved in blocks from becoming tangled during moving or storage: Pull the two blocks apart until the free end of the rope extends only a little beyond a movable block. Bring the blocks side by side, forming a loop in the ropes between the blocks. With the free end of the rope, make one or two half hitches around the loop, and then pass the free end through the loop (see Fig. 8-52).

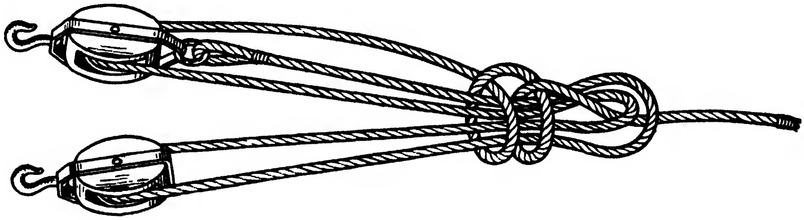


Fig. 8-52. A good way to keep a tackle from tangling when not in use.

Relieving kinks A load should not be placed on a rope that is kinked, as this would put severe strain on certain fibers and weaken them, or possibly break them, and thus shorten the life of the rope. A new rope frequently tends to kink or twist. This is because the right- and left-hand twists of the fibers, yarns, and strands have not become equalized. The trouble can be remedied, in the case of a short rope, by fastening one end to an overhead beam or support and tying a weight to the free end. If care is used, a long rope may be dragged *slowly for a short distance* over a *smooth* surface, thus allowing the free end to revolve and equalize the twists in the parts of the rope. It is extremely important that the rope be dragged *slowly* and *not too far.* Otherwise, the rope may be damaged by abrasion. Rope should not be dragged over sandy or gritty surfaces, as small particles of grit may become embedded in the rope and later cause serious internal wear between the fibers.

Preventing mechanical injury Do not draw a rope over rough or sharp objects, as this might break the outer fibers. Also, keep ropes from rubbing against each other as much as possible when in use in a tackle. Do not bend rope too sharply or use it in pulleys that are too small. The diameter of the pulleys should be at least eight times the diameter of the rope.

Storing rope Store rope in a dry, well-ventilated place. Do not expose ropes to dampness or moisture more than necessary when in use, and if they should become wet, hang them up to dry as soon as possible, as dampness causes rotting of the fibers. It is best to hang rope in loose coils on wooden pegs or arms, rather than leave it piled on a floor.

Chemicals or fumes from chemicals should be carefully avoided, as they cause very rapid deterioration of rope fibers. Keep rope out of the reach of animals and away from fertilizer, manure, decaying vegetable matter, and similar materials.

Inspecting rope To determine the general condition of a rope, grasp it with the two hands a few inches apart and untwist the strands slightly. Internal wear is indicated by rope dust, exposed ends of broken fibers, and distinct edges on the inside of the strands. Extreme

softness or the presence of mildew or mold suggests a weakened condition of the rope.

JOBS AND PROJECTS

1. Make a general study of the various methods that may be used for keeping the ends of a rope from untwisting and becoming frayed. Compare the different methods as to advantages, disadvantages, ease of making, permanence, etc. Learn and be able to demonstrate quickly two or three or four of the ones you consider to be best for farm use.

2. Make a list of six or eight knots and hitches (exclusive of end knots) that you consider to be most useful on the farm. Practice making them until you can make them quickly and easily.

3. Under what conditions would you recommend the short splice, and under what conditions the long splice? What is the difference between the eye splice and the loop splice? How could you splice a rope into a second one at a point some distance from its ends? How could a broken strand be repaired?
   Gather up ropes you can find that need splicing or repairing, and put them in first-class condition. Practice making the long splice, the short splice and the eye splice until you can make them quickly and easily.

4. What knots, hitches, or splices should one know in order to make good rope halters? Compare the various halters described in the foregoing pages, and list those features you consider to be good and those you consider not so good. Make a rope halter you consider to be particularly good, possibly one of your own design.

5. What is the best way to take care of a rope when it is not in use? Make a list of all the rope you keep about your home or farm. Is it stored so as to best preserve it when not in use? If not, make provisions for its proper storage.
   Outline methods for removing kinks from ropes. How may ropes be coiled and uncoiled so as to avoid kinking? Why does a new rope tend to kink.

6. Outline methods you would use for casting and holding a steer. Also outline a method for casting a horse.

7. Outline safety precautions to be observed in using blocks and tackle. How may a set of blocks and tackle be arranged for storage or moving so to avoid tangling.
   What is meant by the mechanical advantage of a set of blocks and tackle? How may the mechanical advantage of a set be determined at a glance?

8. Take two blocks and a rope, and demonstrate exactly how to reeve the blocks.

9 LEATHER WORK

1. Making a Waxed Thread
2. Making a Sewed Splice
3. Making a Riveted Splice
4. Attaching Snaps and Buckles
5. Cleaning, Oiling, and Preserving Leather

WORKING in leather is not difficult for anyone with a moderate amount of mechanical ability or one who commonly does shopwork in wood or metal. Only a few rather simple tools are required.

1. MAKING A WAXED THREAD

To make a sewed splice, it is first necessary to make a waxed sewing thread. Three to five strands of No. 10 linen thread are needed.

Tearing the thread Draw the desired length of thread, usually about 5 ft, from the ball and tear it off. Do not cut it off. To tear

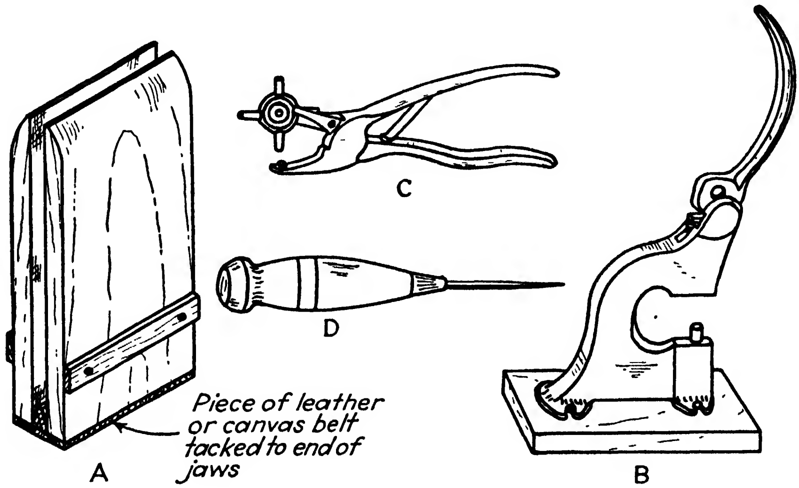


Fig. 9-1. Leather-working tools: *A*, homemade leather-sewing clamp for use in a vise; *B*, hand machine for using tubular rivets; C, leather punch; *D*, sewing awl.

the thread, untwist it for a distance of 6 to 8 in. at the point to be torn, and then jerk it apart. It will tear at about the middle of the untwisted part. A good way to untwist the thread for tearing is to roll it between the palm and the right thigh (see Fig. 9-2*A*), while holding it with the left hand at a point about 8 in. away from the thigh. A

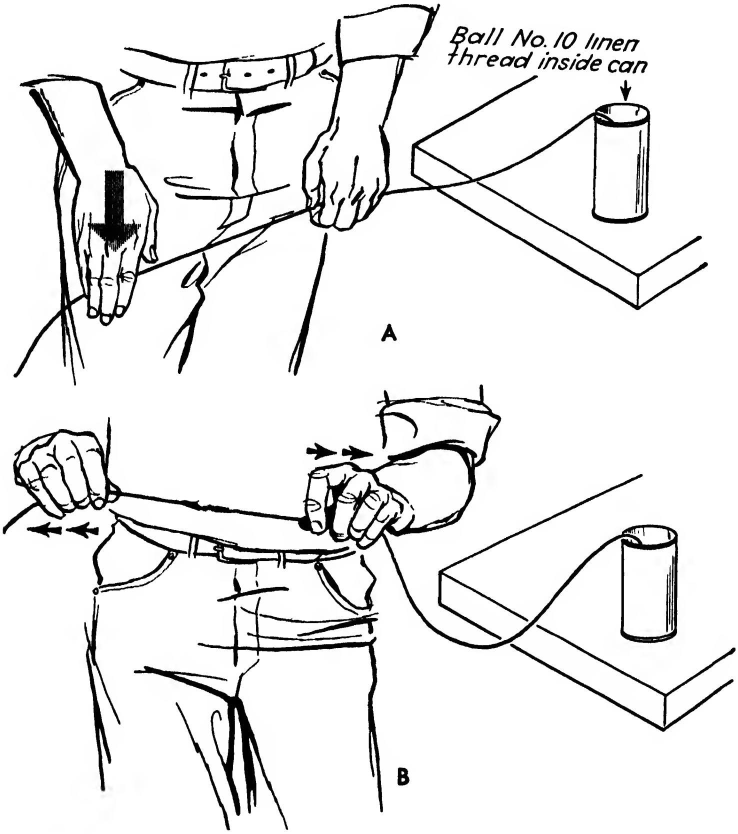


Fig. 9-2. Leather-sewing thread should be torn, not cut. First draw the desired length from the ball and untwist it by rolling over the thigh, as at *A*. Then tear it apart with a few short, quick jerks, as at *B*.

few short quick jerks (see Fig. 9-2*B*) are all that is required to tear the untwisted thread.

Thread should be torn instead of cut in order to give a long tapered end that can be threaded easily into the eye of a sewing needle.

To keep the supply of thread from becoming tangled, the ball may be kept in a small can.

Assembling the threads After the desired number of strands, usually three or four, have been withdrawn from the ball and torn off to approximately the same length, assemble them with the ends offset or staggered (see Fig. 9-3), extending the first strand about 1½ in. beyond

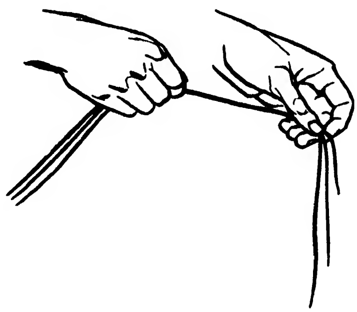


Fig. 9-3. To give a fine tapering point to the finished thread, the individual strands are assembled with ends offset or staggered.

the second, and the second about 1½ in. beyond the third, and so on. Staggering the ends gives a long, finely tapered point to the sewing thread.

Waxing the ends of the threads After the strands have been assembled, wax the tapered ends by rubbing them with a small piece of *harness-maker's wax* (see Fig. 9-4). A good way to keep and use

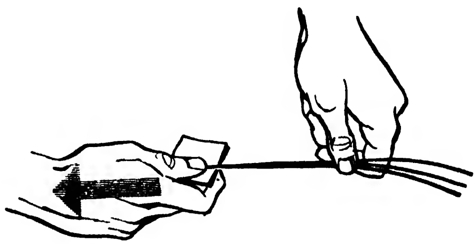


Fig. 9-4. After assembling the strands, wax the ends.

the wax is to put it on a pad of scrap leather. In cold weather, it may be desirable to warm the wax a little.

Twisting and waxing the threads After the ends are waxed, stretch the thread over a nail or hook and twist it, one end at a time, by rolling it over the right thigh with the palm of the right hand (see Fig. 9-5). Hold one end of the thread tight in the left hand, and catch and hold the twist as it is made in the other end by rolling. After both ends are twisted, pull the thread back and forth over the hook in order to even the twist in the two ends. A little practice will indicate how

much to twist the thread. Too much twist will cause serious kinking and tangling, and too little twist will cause the thread to be flat instead of round. The thread should kink slightly when slack, however. Otherwise, it will be flat and not round and firm when sewed into leather. It is a common mistake among beginners not to twist enough.

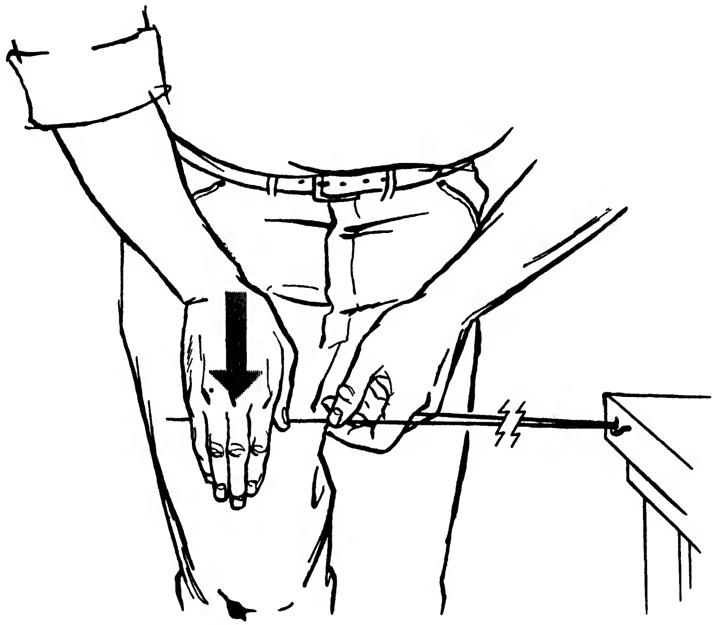


Fig. 9-5. Twist the thread by running it around a nail or hook and then rolling it over the thigh, one end at a time.

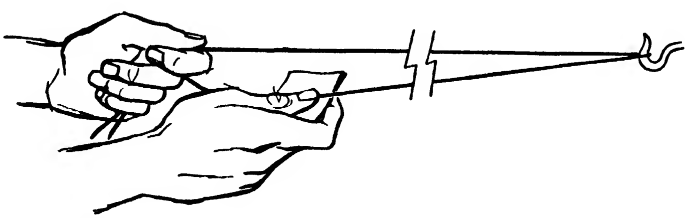


Fig. 9-6. After twisting, wax the thread. Apply only a moderate amount of wax and work it in well.

After the thread is twisted, wax it by rubbing the wax back and forth along the thread several times (see Fig. 9-6). Then rub the thread with a piece of leather or with the thumb and fingers to work the wax in and distribute it evenly. Apply enough wax to make the thread black all over after it is well distributed. If the thread is sticky,

rubbing it with a piece of *beeswax* will help, but keep beeswax off the ends that go through the needles.

Attaching the needles Fasten a blunt-pointed leather-sewing needle on each end of the waxed thread in the following maner:

1. Put the end of the thread through the eye of the needle, and push the needle back on the thread about as far as it will go without ruffling up the thread, usually about 2 or 3 in.
2. Fold the pointed end of the thread back alongside the main thread, and hold the doubled thread close to the needle with the thumb and first finger of the left hand (see Fig. 9-7).

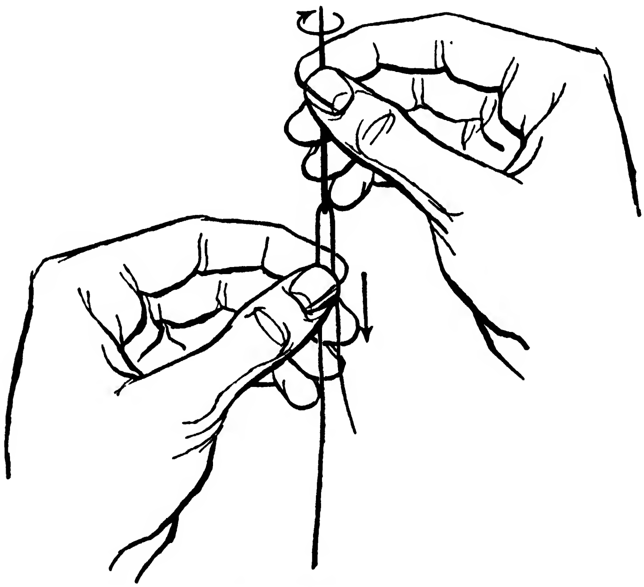


Fig. 9-7. Fastening a needle to the end of the thread. After threading, roll the needle in a clockwise direction and slowly move the left thumb and finger down the thread.

3. Twist the needle clockwise by rolling it between the right thumb and finger while the left thumb and finger move slowly down the thread from the needle.

The end of the thread is thus twisted around and worked into the main thread, and the wax holds it in place. When this is carefully done, the thread just back of the needle is about the same size as the needle.

2. MAKING A SEWED SPLICE

Preparing the ends to be spliced Cut the ends of the pieces of leather square and bevel them back about 2 in. (see Fig. 9-8). Use a sharp knife or carpenter's plane, and do all beveling on the rough, or flesh, side of the leather. The hair, or smooth, side is tougher and

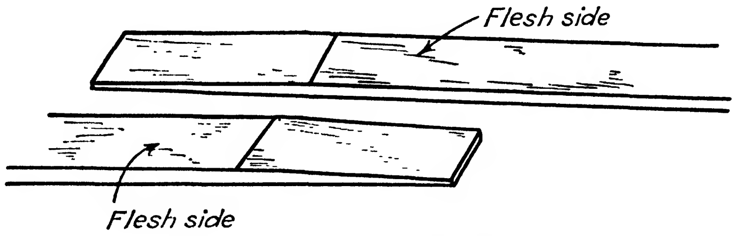


Fig. 9-8. Ends of straps beveled ready for sewing.

stronger and should not be cut away in beveling. Do not make the tip ends of the pieces too thin, but leave them about half the normal thickness of the leather.

Stitching the splice After the ends are beveled, lap them together about 3½ or 4 in., and place them in a stitching vise or clamp. Be sure to have the hair side of both pieces to the right, and the end nearest you to the right. Place the ends in the clamp so that their top edges project above the jaws of the clamp about ¼ in. or a little less.

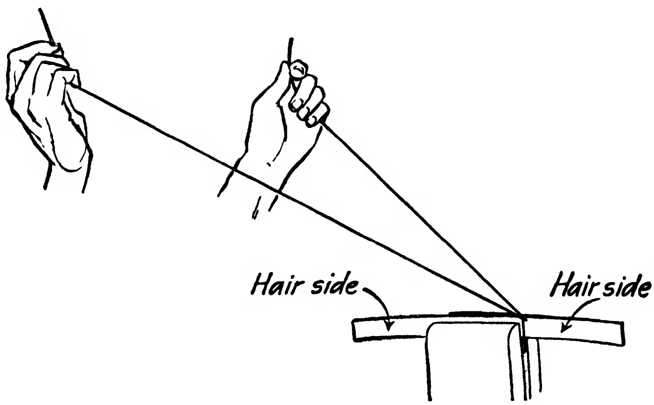


Fig. 9-9. Starting the stitching. Place the hair side of both pieces to the right. The end nearest the worker should be to the worker's right. Punch an awl hole in the single strap just beyond the splice, insert one needle, and draw the thread halfway through.

A simple homemade clamp (Fig. 9-1*A*) used in a woodworking or metalworking vise is quite satisfactory.

Punch an awl hole in the single strap beyond the splice, place one needle through the hole, and draw the thread about halfway through (see Fig. 9-9). Punch the second hole through both pieces and about $\frac{3}{16}$ in. from the first. Insert the left needle, and pull the thread through a little way. Then insert the right needle and pull both threads up tight, keeping the awl in the right hand all the time. In this manner, continue stitching to the end of the splice.

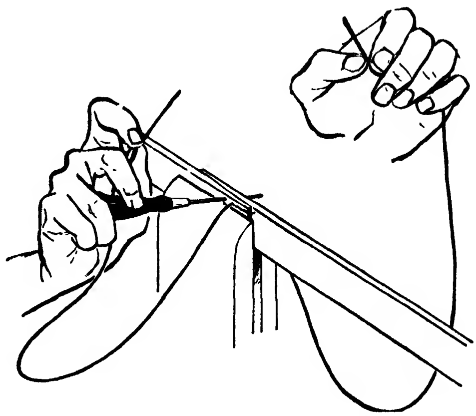


Fig. 9-10. Keep the awl in the right hand all the time while sewing.

Punching the awl holes If desired, a line may be marked or creased in the leather about $\frac{3}{16}$ in. from the edge to serve as a guide for the awl holes. This line may be marked with a creasing tool, or a pencil, or one leg of a pair of dividers drawn along a straight edge.

The spacing of the holes may be marked off with a stitching wheel or with a pair of dividers, although this is hardly necessary. With a little practice, the awl holes may be spaced evenly by eye and without first measuring and marking them.

The awl makes a diamond-shaped hole. Hold the awl so as to place the long axis of the diamond about halfway between the vertical and the horizontal (see Fig. 9-11). Make only one hole at a time,

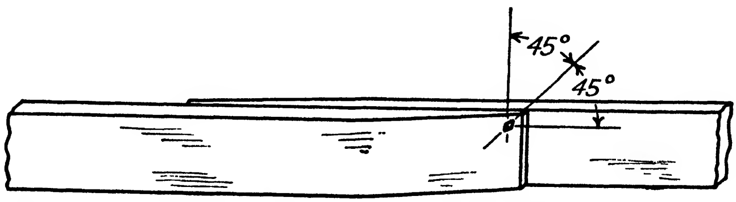


Fig. 9-11. The awl makes a diamond-shaped hole. Hold the awl so as to place the long axis of the diamond about halfway between the vertical and the horizontal.

following up immediately with the sewing thread. If several holes are punched before sewing, there will be difficulty in keeping the holes aligned in the two pieces of leather.

Making the crossover When the stitching has proceeded across one side of the splice, punch an awl hole through the single strap just beyond the lap. Put both needles through it in the usual manner. Punch a second hole through the single strap, and put the right needle through it. This brings both threads out on the left, or flesh, side of the leather (see Fig. 9-12).

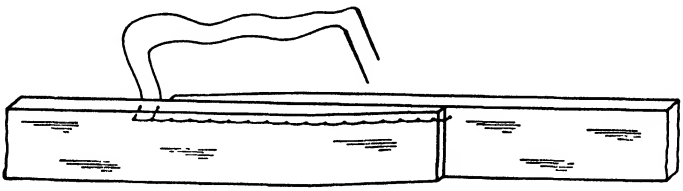


Fig. 9-12. Step one in making the crossover.

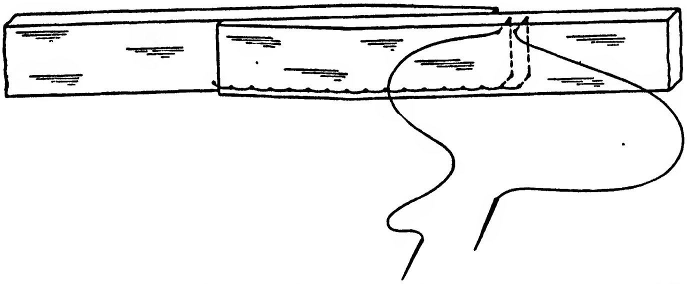


Fig. 9-13. Step two in making the crossover. Turn the splice upside down and end for end in the clamp.

Turn the splice upside down and end for end in the clamp. Punch two holes in the single strap just beyond the lap. Put one needle through each of these holes, bringing both threads to the right, or hair, side of the leather (see Fig. 9-13). Take the needle coming through the farthest hole and put it back through the hole nearest the lap, leaving a thread on each side of the splice (see Fig. 9-14). Then stitch the second edge of the splice in exactly the same manner as the first.

Anchoring the threads To prevent the stitching from loosening, the threads may be anchored as follows: Take one regular stitch through the single strap just beyond the splice. Then make an anchor

stitch back in the double part of the splice, in line with the last stitch in the double part, but about $\frac{3}{16}$ in. in toward the center of the straps (see Fig. 9-15). To make this anchor stitch, place both threads through the hole in the usual manner, but draw only one thread, say the one coming through from the left side, up tight. Then wrap this left thread

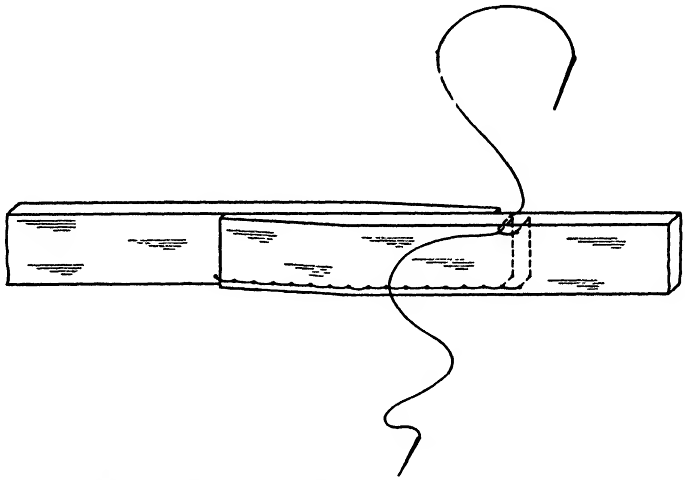


Fig. 9-14. The crossover completed and the splice ready to be stitched along the second edge.

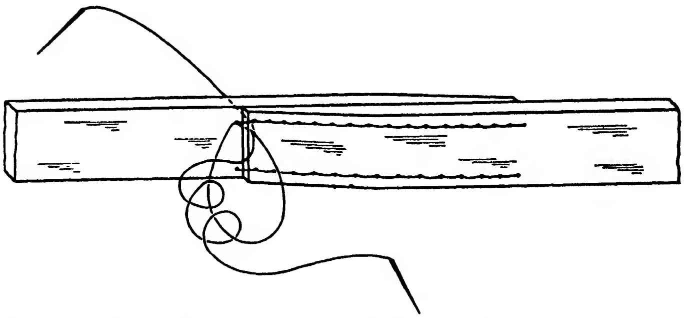


Fig. 9-15. Making the lock stitch to prevent the sewing from loosening.

twice in a counterclockwise direction through the loop made by the other thread. Draw both threads up tight. This wraps the threads around each other in the hole. Then cut the threads off.

Some prefer not to make the crossover at all, but to stitch each side of the splice separately and anchor the threads at the end of each side.

After the sewing is done, the splice may be hammered lightly with

a smooth-faced hammer or rubbed with a piece of leather to work the stitches in and smooth the wax.

3. MAKING A RIVETED SPLICE

To make a riveted splice, first bevel the ends of the pieces and lap them in the same manner as for stitching. If solid rivets are to be used, punch holes with a hollow-bit punch (Fig. 9-1*C*) or with a punch-type knife blade that will cut a round hole. To complete the job, insert the rivets, place burrs (washers) on the ends, and rivet them in place. This kind of riveting is recommended where permanent repairs are being made.

Riveted splices may be quickly and easily made with a hand riveting machine (Fig. 9-1*B*) which uses hollow or tubular rivets (Fig. 9-16*B*).

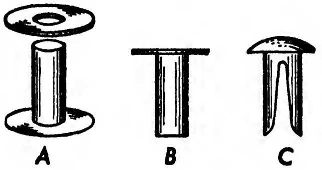


Fig. 9-16. Styles of leather rivets: A, solid rivet with burr; B, tubular rivet; C, split rivet.

Such rivets cut or punch their own holes. They are commonly used where repairs must be made quickly, and they are excellent for this purpose. To use a hand riveting machine, simply place a rivet in the machine, put the pieces of leather to be joined in the machine, and press down on the handle. Use at least two rivets in each splice.

Another type of rivet sometimes used for riveting leather is the split rivet, which has two prongs (Fig. 9-16*C*). To use such a rivet, simply drive it through the leather with a hammer, and then bend the prongs over to clinch them and hold the rivet in place. By careful manipulation, or by placing the leather against a piece of iron while the rivet is being driven, the ends of the prongs may be turned back and made to clinch themselves in the leather.

4. ATTACHING SNAPS AND BUCKLES

A buckle or snap may be attached to a piece of leather by (1) sewing, (2) riveting, (3) both sewing and riveting (see Fig. 9-17), or (4) using a special loop or piece of leather hardware (Fig. 9-18).

Sewing and riveting is probably best, although simply riveting or using a special piece of leather hardware is easier and faster and for many purposes quite satisfactory.

To attach a buckle to a leather strap by sewing or riveting, first cut the end of the strap off square, and round the corners slightly. Then

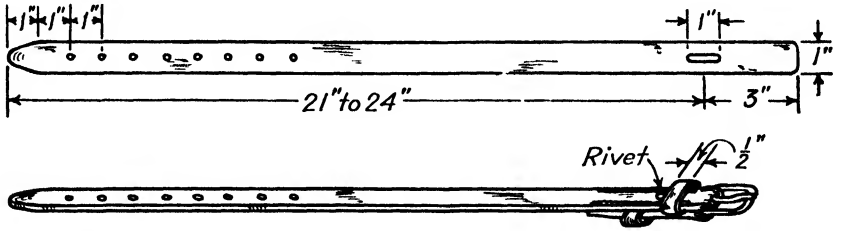


Fig. 9-17. A homemade belt or strap. The buckle is attached by sewing and riveting.

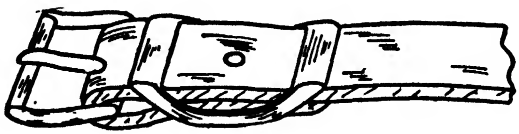


Fig. 9-18. A buckle attached to a leather strap by a piece of special leather hardware known as a conway loop.

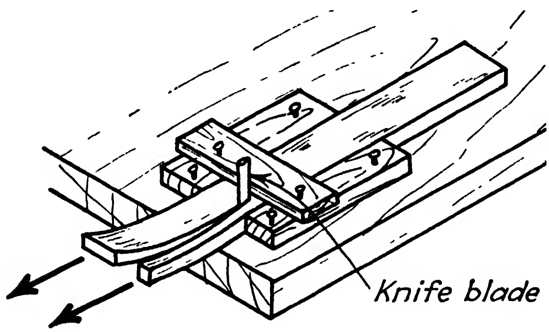


Fig. 9-19. A convenient method of splitting leather. A knife blade stuck into the bench top does the cutting, and a few strips of thin wood tacked to the bench guide the strap as it is pulled through.

bevel the strap on the rough, or flesh, side back about an inch from the end. Make the slot for the tongue of the buckle by punching two holes in the leather about an inch apart and then cutting out between the holes with a sharp knife. If desired, a leather loop or keeper may be sewed into place by careful work (see Fig. 9-17).

5. CLEANING, OILING, AND PRESERVING LEATHER

Leather may be cleaned by washing with warm water and mild soap or warm water and sal soda. A good way to clean a harness is to take it apart and soak it in a tub of warm water into which a handful of sal soda has been dissolved, and then to scrub it with a stiff brush. A sloping drainboard or a shallow trough with the upper end supported on a sawhorse and the lower end on the tub makes a good place to wash and scrub parts of a harness.

After washing leather, hang it in a warm room to dry. While it is still slightly damp, apply a good grade of leather dressing or harness oil by rubbing with a sponge or cloth. As the moisture dries out, the oil penetrates into the leather and helps to preserve it and keep it pliable. Use only a good leather dressing or harness oil or a compound of animal oils such as neat's-foot oil and tallow in oiling leather. Do not use motor oil or machine oil because of the detrimental effect on leather.

JOBS AND PROJECTS

1. Make a waxed harness-sewing thread, fasten on the needles, and make one or two practice splices in short pieces of leather.

2. Examine your work carefully for such points as uniform stitches, well-waxed and twisted thread which does not become flat, line of stitching uniform distance from edge of leather, and secure anchoring of ends of thread.

3. Clean, repair, and oil a harness. Take it apart and wash it, and restitch or repair with rivets wherever needed before oiling.

4. Make a hame strap, a dog collar, or some other piece of leather work, possibly even a halter, for which you have need.

10 CONCRETE WORK

CONCRETE is an ideal material for walks, steps, water tanks, foundations, floors, barn-lot pavements, and many other construction jobs about the farm. It is economical, durable, sanitary, and attractive in appearance.

A large percentage of the concrete used on farms is ready-mixed and delivered to the job in large trucks. For the larger farm jobs and also for many of the smaller ones, this is usually more practical than getting materials and mixing them on the job, because it saves time and labor.

It is as easy to make good concrete as poor concrete. Observing a few simple principles makes the difference. Concrete is simply a mass of sand and gravel held together by a cement paste that has hardened. The paste is made of portland cement and water. If the paste is rich and strong, the concrete will be strong. On the other hand, if the paste is weak and watery, or if the work is carelessly done, the concrete will be weak and poor.

1. SELECTING GOOD MATERIALS

Good-quality concrete depends upon the use of good materials. The materials for making concrete are (1) fine aggregate (usually sand), (2) coarse aggregate (pebbles, gravel, crushed stone, etc.), (3) portland cement, and (4) water.

Fine aggregate includes all particles from very fine (exclusive of dust) up to and including those which will just pass through a screen having meshes ¼ in. square. Coarse aggregate includes all pebbles or broken stone ranging from ¼ in. up to 1½ or 2 in. The maximum size of coarse aggregate to be used is governed by the nature of the work.

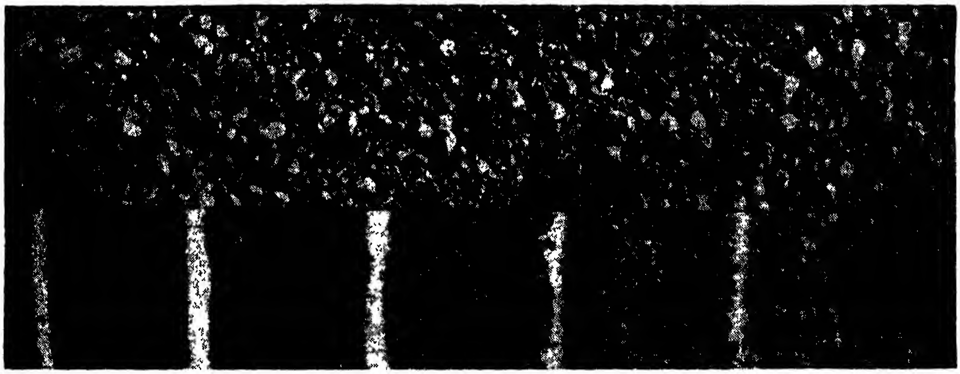


Fig. 10-1. A sample of well-graded sand before and after it has been separated into various sizes. Particles vary from fine up to pebbles that will just pass through a 1/4-in. mesh screen. (Portland Cement Association)

Usually, the largest dimension of any piece of aggregate should not exceed one-third the thickness of the slab or wall in which it is used.

Sand Sand should be hard and clean, that is, free of dust, loam, clay, and vegetable matter. These foreign materials are objectionable because they prevent a good bond between the cement and the particles of sand, and thus reduce the strength of the concrete and increase it porosity. Concrete made with dirty sand or pebbles hardens slowly at best and may never harden satisfactorily.

Sand should be well graded, that is, the particles should not be all fine or all coarse, but should vary from fine to the size that just pass a screen having meshes ¼ in. square (see Fig. 10-1). If the sand is well graded, the finer particles help to fill the spaces between the larger

particles. A given amount of cement will then bind together a greater amount of aggregate and will thus increase the amount of concrete that can be made from a sack of cement.

Coarse aggregate Pebbles or crushed stone to be used in a concrete mixture should be tough, fairly hard, and free from any of the impurities that would be objectionable in sand. It is desirable also that

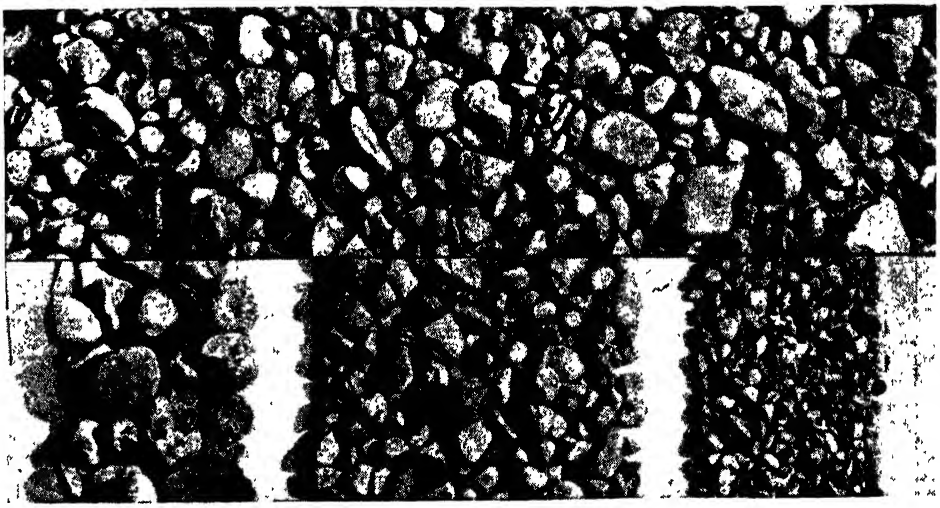


Fig. 10-2. A sample of well-graded coarse aggregate before and after it has been separated into various sizes. Note the variety of sizes, the smaller stones filling in the spaces between the larger ones. (Portland Cement Association)

coarse aggregate be well graded for the same reason that it is desirable that sand be well graded (see Fig. 10-2).

Bank-run gravel The natural mixture of sand and pebbles as taken from a gravel bank is usually referred to as *bank-run material.* In bank-run material, fine and coarse aggregate are seldom present in the right proportion to produce a good, workable, economical mixture. Most gravel banks contain too much sand. Money can usually be saved by screening out the sand and then recombining the materials in the correct porportions.

Cement Many brands of portland cement are on the market. Practically all are made to meet standards adopted by the United States government and the American Society for Testing Materials.

Therefore, cement that is bought from reputable dealers and stored properly may be expected to give satisfactory results.

Always store cement in a dry place, as it has a tendency to absorb moisture and become lumpy. It may be desirable to keep a sack or two on hand for an occasional small repair job, but it is usually best to buy cement for the larger jobs only shortly before it is to be used. Keep stored cement up on boards away from contact with either the floor or the ground; otherwise it may absorb moisture and harden and become worthless. Any cement containing lumps so hard that they do not readily pulverize when struck lightly with a shovel should not be used.

Water Water used to mix concrete should be clean and free from oil, alkali, and acid. In general, water that is fit to drink is good for concrete.

Testing sand and gravel for silt Sand and gravel may be easily tested to determine if they contain injurious amounts of fine clay or silt as follows (see Fig. 10-3):

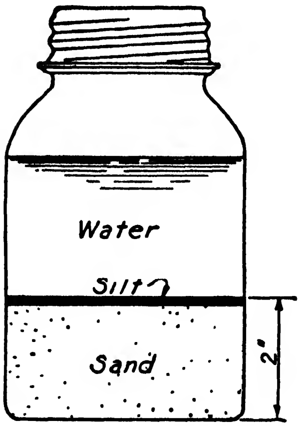


Fig. 10-3. If a 2-in. sample of sand contains more than 1/8 in. of silt, the sand should be washed or rejected.

1. Place 2 in. of a representative sample of the sand or gravel in a pint fruit jar.
2. Add water until the jar is almost full, fasten the cover, shake vigorously, and then set the jar aside until the water over the material becomes clear.
3. Measure the layer of silt on top of the sand or gravel. If the layer is more than ⅛ in. thick, the material is not clean enough for concrete.

Washing sand and bank-run gravel Sand and gravel containing too much silt or clay may be washed on a wide, shallow, sloping trough (see Fig. 10-4). To wash the material, shovel it onto the high end, and drench it with water by means of a hose, pipe, or pail, washing out the objectionable silt or clay. Retest the material after washing to make sure that it is clean.

Testing sand and gravel for vegetable matter A test to see whether sand or gravel contains too much decomposing vegetable matter for use in concrete may be made as follows:

1. Place ½ pt of water in a colorless 1-pint fruit jar, and dissolve a heaping teaspoonful of household lye in it.
2. Pour ½ pt of a representative sample of the sand or gravel into the jar containing the lye water.
3. Cover the jar, and shake vigorously for 1 to 2 min.
4. Set the jar aside for 24 hr, and then inspect it in a good light.

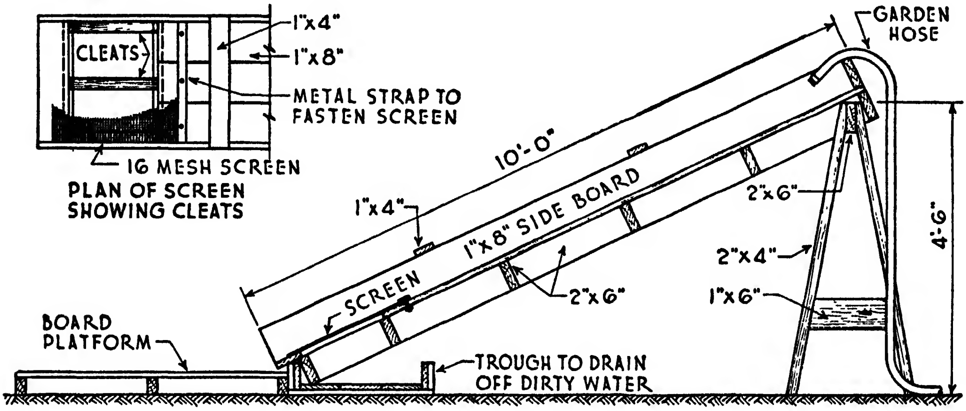


Fig. 10-4. A sloping trough for washing sand and gravel. (Portland Cement Association)

5. If the water is clear or colored not darker than cider vinegar, the material is suitable for use in concrete. If the water is darker than this, however, the material should not be used unless it is washed first to remove the objectionable vegetable matter.

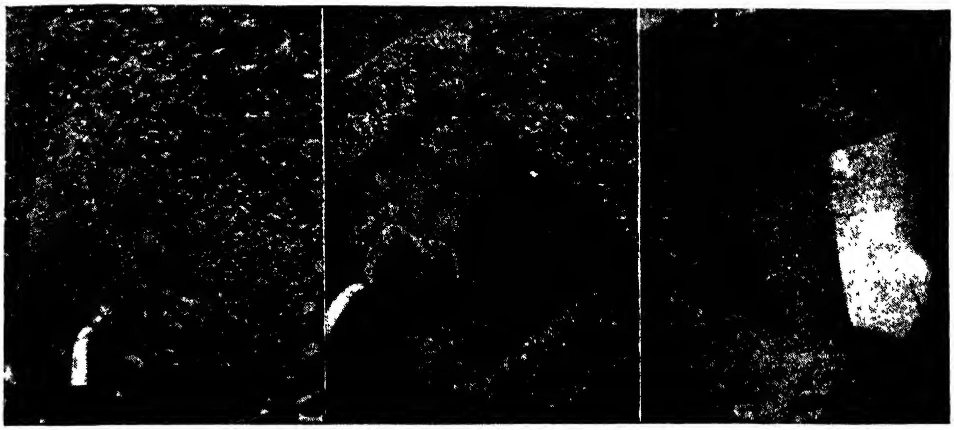
2. DETERMINING PROPORTIONS OF MATERIALS

Table 10-1 gives suggested mixes for various kinds of concrete work on the farm. The 1-2¼-3 mix (1 sack of cement to 2¼ cu ft of sand and 3 cu ft of gravel) is used for most jobs. The mixes suggested in the table are for average conditions and may be used as trial mixes. The proportions of sand and gravel may be changed slightly if necessary to give workable mixes. Do not use more water per sack of cement than suggested, however, as this will produce a weaker concrete. By a workable mix is meant one that is smooth and plastic and that will place and finish well. It should not be so thin that it runs, nor so stiff that it crumbles (see Fig. 10-5). It should be rather sticky when worked with a shovel or trowel. For most jobs, a workable mix is one that is "mushy" but not "soupy."

TABLE 10-1. Suggested Trial Proportions of Water, Cement, Sand, and Gravel,* and Approximate Amounts of Materials Required for Farm Concrete

Type of concrete	Water-cement ratio, gal of water per sack of cement	Gal of water to add for each 1-sack batch			Trial amounts of sand and gravel per sack of cement		Maximum size of gravel, in.	Approximate amounts of material required per cu yd of concrete		
		Damp sand	Average sand	Very wet sand	Sand, cu ft	Gravel, cu ft		Cement, sacks	Sand, cu yd	Gravel, cu yd
Concrete subject to severe wear, weather, or weak acid or alkali solutions, fence posts, lawn or garden furniture, very thin concrete	5	4 1/2	4	3 3/4	1 3/4	2	3/4	8	1/2	6/10
Most farm construction such as floors, walks, yard pavements, water tanks, and septic tanks	6	5 1/2	5	4 1/4	2 1/4	3	1 1/2	6 1/4	1/2	7/10
Foundation walls which do not need to be watertight, footings, retaining walls, mass concrete	7	6 1/4	5 1/2	4 3/4	2 3/4	4	1 1/2	5	1/2	3/4

* These are for trial mixes for average conditions. Change proportions of sand and gravel slightly if necessary to get workable mixes, but do not use more water per sack of cement than suggested.



A B C

Fig. 10-5. Mixes with different degrees of workability. *A* does not contain enough cement-sand mortar to fill the spaces between pebbles. This mix is hard to work, rough, and porous. *B* has an excess of mortar. It is plastic and workable but is expensive owing to the small yield per bag of cement. It is also likely to be porous. C contains the correct amount of mortar. With light troweling the spaces between pebbles are filled. Note how it hangs together on the edges of the pile. This mix gives maximum yield of concrete and produces smooth, dense surfaces. (Portland Cement Association)

3. ESTIMATING QUANTITIES OF MATERIALS NEEDED

The amounts of cement, sand, and coarse aggregate needed for a given job may be estimated closely by first figuring the volume of concrete to be made, and then using tables such as Tables 10-1 and 10-2. The quantities given in these tables are for average conditions, and in any particular case the quantities needed may vary 5 or 10 percent from those given.

Suppose, for example, that a concrete tank is to be built and the volume of the forms is figured to be 46 cu ft, or approximately 1¾ cu yd. As shown in Table 10-1, 1 cu yd of 1-2¼-3 concrete requires approximately 6¼ sacks of cement, ½ cu yd of sand, and 7/10 cu yd of gravel. Since 1¾ cu yd of concrete is needed, the *approximate* amounts of materials may be found as follows:

1 3/4 × 6 1/4 = 11 sacks of cement
1 3/4 × 1/2 = 7/8 cu yd of sand
1 3/4 × 7/10 = 1.1/4 cu yd of gravel

It is usually good practice to allow a little extra, say 5 to 10 percent, for waste and variations in the work.

TABLE 10-2. Approximate Amounts of Materials Required per 100 Sq Ft of 1–2 1/4–3 Mix Concrete

Thickness of concrete, in.	Concrete, cu yd	Sacks of cement	Sand, cu yd	Gravel, cu yd
4	1 1/3	7 3/4	3/4	1
6	2	11 2/3	1	1 1/3
8	2 1/2	15 1/2	1 1/3	1 3/4
10	3	19 1/3	1 3/4	2 1/4
12	3 3/4	23	2	2 2/3

TABLE 10-3. Approximate Amounts of Materials Required per 100 Sq Ft of Portland Cement Mortar or Concrete

Thickness of mortar or concrete, in.	Amount of mortar or concrete, cu yd	Mix Proportions				
		1–3		1–1 3/4–2 1/4		
		Sacks of cement	Sand, cu ft	Sacks of cement	Sand, cu ft	Gravel (3/8 in.) cu ft
3/8	1/8	1	3			
3/4	1/4	2	6			
1	1/3	2 3/4	8	2 2/3	6	7
1 1/2	1/2	...	..	4	8	10
3	1	...	..	8	16	19

Table 10-2 may be used for figuring the amounts of materials needed for floors, walls, or other plain flat slabs of concrete of the most commonly used mix, 1-2¼-3. For example, the materials needed for a basement floor 20 by 30 ft and 4 in. thick may be computed as follows: From Table 10-2, 100 sq ft of concrete of this mix and 4 in. thick requires 7¾ sacks of cement, ¾ cu yd of sand, and 1 cu yd of gravel. For 600 sq ft ($20 \times 30 = 600$), the approximate quantities of materials needed would be

$$7\,3/4 \times 6 = 46\,1/2 \text{ sacks of cement}$$
$$3/4 \times 6 = 4\,1/2 \text{ cu yd of sand}$$
$$1 \times 6 = 6 \text{ cu yd of gravel}$$

4. BUILDING AND PREPARING FORMS

Forms, generally made of wood, hold the concrete in place until it hardens. Rough lumber may be used where appearance is not important, but where a smooth finish is desired, the forms should be carefully built of good smooth lumber. Tongue-and-groove lumber or shiplap is commonly used to give tight joints. Construct forms so

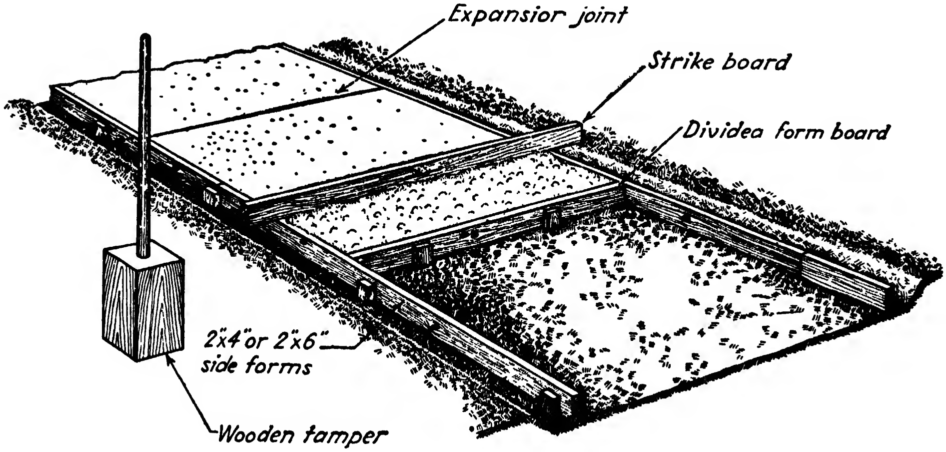


Fig. 10-6. Forms for a concrete sidewalk. Concrete walks are often poured in alternate sections. After these harden, the intermediate sections are poured. (Portland Cement Association)

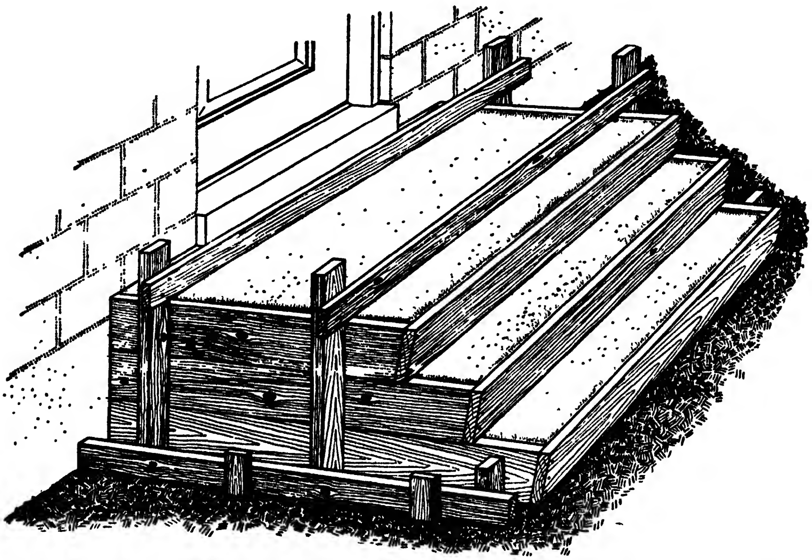


Fig. 10-7. Simple forms for building concrete steps. (Portland Cement Association)

that they can be easily removed without damage to the fresh concrete and with the least possible damage to the form lumber. Where forms are to be used again, they may be built in sections to facilitate removal and reassembly.

It is important that forms be built tight and strong and that they be well braced in position to prevent bulging or leaning when the wet concrete is tamped into place. Wood forms are commonly oiled with

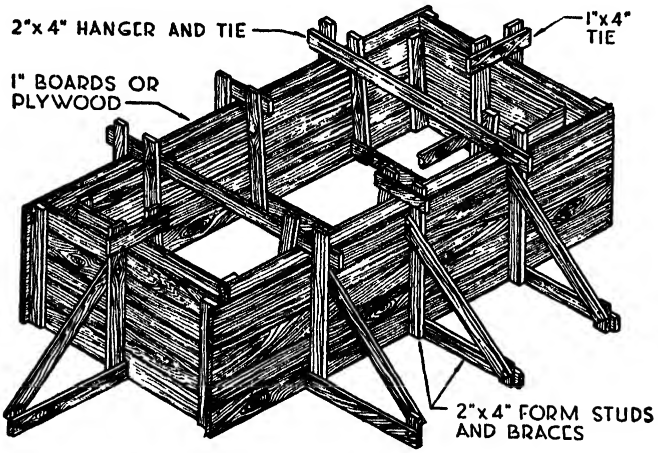


Fig. 10-8. Forms for a livestock-watering tank. (Portland Cement Association)

used engine oil to prevent warping and to prevent the concrete from sticking to them.

For foundation work below ground, forms are not necessary if the soil will stand without caving or crumbling and the excavation is carefully dug to size (see Figs. 3-128 and 3-129, page 131).

5. REINFORCING CONCRETE

Concrete, like stone, is strong in compression and can support very heavy loads that tend to mash or crush it. Steel rods or other forms of reinforcement should be used, however, where the loads or forces tend to pull it apart or bend it. It is important that the reinforcement be placed where it will do the most good in helping to resist the pulling or bending forces. For example, in a concrete beam, as a lintel over a window or a door, place the reinforcement near the lower side, for this is the side that tends to stretch or pull apart when the beam is loaded. Large or important concrete structures, such

as floors above ground, beams, columns, and storage bins, should be designed and have the reinforcement specified by a competent engineer or builder. Plans for many concrete farm structures are available from agricultural colleges. These usually have the amounts and placement of reinforcement indicated.

Steel reinforcing bars and wire mesh are generally used for reinforcement. Do not use scrap iron and rusty fence fire. Reinforcement

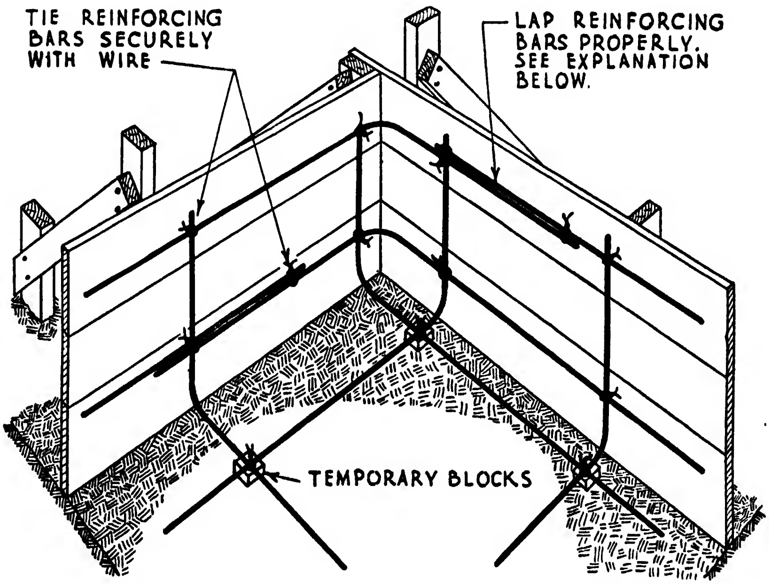


Fig. 10-9. Reinforcing bars should be carefully lapped at the joints and securely tied and supported in place to ensure proper location after the concrete is poured. (Portland Cement Association)

should be free from rust and other coatings. Place reinforcement carefully as may be specified in plans, and then securely wire or anchor it to prevent dislodging when the concrete is poured (see Fig. 10-9). Lap the ends of steel bars a distance of 12 in. for each ¼ in. of diameter. For example, ¼-in. bars should be lapped 12 in.; ⅜-in. bars, 18 in.; ½-in. bars, 24 in.; etc.

6. MEASURING AND MIXING THE MATERIALS

Measure all materials, particularly water, which go into a batch of concrete. It is especially important that only a limited, measured amount of water be used for each sack of cement. Too much water

results in a weak cement paste and weak, porous concrete which is sure to be unsatisfactory.

Machine mixing Mixing should be done by machine wherever possible, because of the saving in time and labor and the ease with which a thorough job can be done. A good way to proportion and mix the materials when a mixer is used is as follows: Put all the water required for a batch into the mixer. Add four or five shovelfuls of gravel. Next add all the cement required for the batch, and then

Fig. 10-10. Ready-mixed concrete is available in many places. Its use saves time and labor and is often more practical than mixing the materials on the job.

shovel in the remainder of the gravel and sand, keeping count for the shovelfuls of each. Run the mixer 1 to 2 min after all the materials are in it.

It is common practice to mix a ⅓-sack batch, a ½-sack batch, a ¾-sack batch, or a 1-sack batch, depending upon the size of the mixer. To determine the size and number of shovelfuls of cement to use, empty a sack of cement into a box or wheelbarrow or other container and shovel it into another box or container, regulating the size of shovelfuls so as to require about 10 to a sack. If a ½-sack batch is to be mixed, then use 5 shovelfuls; if a ⅓-sack batch is to be mixed, then use slightly larger shovelfuls (9 to a sack) and 3 of them to a batch, etc.

A little experimenting may be required to determine just the correct number of shovelfuls of sand and gravel to give a workable mix, but once the correct number is determined, then it is easy to load the mixer each time with the correct number of shovelfuls of cement and sand and gravel.

Hand mixing When concrete is mixed by hand, a different method is generally used for measuring the materials. Small batches are easily proportioned by measuring in pails. For example, 1-2¼-3 batch could

Fig. 10-11. Machine mixing is preferred to hand mixing, because of the saving in time and labor and the ease with which a good job can be done.

be made by taking 1 pail of cement, 2¼ of sand, and 3 of gravel. About ⅔ pail of water would be about the right amount for such a batch, assuming average moist sand. It is best to use two pails of the same size, using one for measuring cement and keeping it dry, and using the other one for the other materials.

The usual procedure for mixing by hand is as follows:

1. Spread the measured amount of sand on a watertight mixing platform or floor and then spread the required amount of cement evenly over the sand.
2. Turn the material with square-pointed shovels until the color becomes uniform and the sand and cement are thoroughly mixed.

There should be no streaks of brown and gray, as such streaks indicate incomplete mixing.

3. Next, measure out the required amount of coarse aggregate, and spread it in a layer on top of the cement-sand mixture.
4. Mix until the pebbles have been uniformly distributed throughout the mass.
5. Then make a depression or hollow in the middle of the pile, and slowly add the correct amount of water while the materials are turned. Continue mixing until all materials are thoroughly and uniformly mixed.

7. PLACING CONCRETE

Place concrete in forms as soon after mixing as possible. Deposit it in layers of uniform depth, usually not exceeding 6 in., and tamp or spade it well as it goes into the forms (see Fig. 10-12), to ensure smooth surfaces and dense concrete. A 1 by 4 board sharpened to chisel point, or a garden hoe with the blade straightened, makes a good concrete spade. Be careful not to dislodge any reinforcement that may have been placed in the forms.

Fig. 10-12. Thorough spading of concrete as it is placed in the forms helps assure smooth, water-tight walls. (Portland Cement Association)

If work must be stopped before the forms are filled, roughen the surface with a stiff broom before it hardens. Then before resuming the placing of concrete, wet the surface and cover it with a layer of cement mortar about ½ in. thick. This helps to make a tight joint between the old and the new work. The mortar may be made of 1 part of cement, 2½ parts of sand, and enough water to give a "mushy" (not "soupy") consistency.

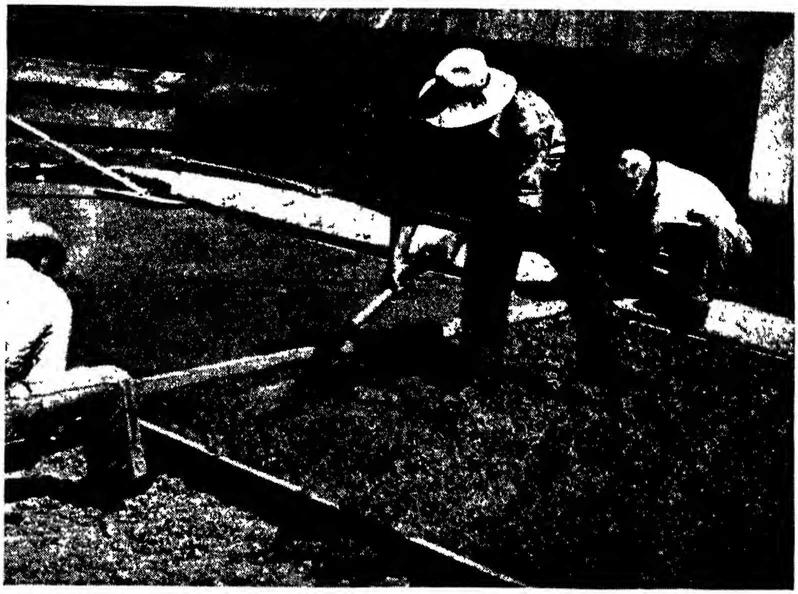


Fig. 10-13. Freshly placed concrete being leveled with a strike-off board. Note that this mix is plastic and workable and levels easily.

8. FINISHING CONCRETE

After concrete is placed, level it off in the forms with a straight-edged board or wood float, and then smooth it with a wood float to make an even surface. Delay further finishing until the concrete is quite stiff.

If a gritty, nonskid surface is desired, as on walks or barn floors,

Fig. 10-14. After concrete becomes quite stiff but is still workable, use the wood float to make a compact, smooth surface. No further finishing is required to produce a gritty, nonslip surface. (Portland Cement Association)

Fig. 10-15. A long-handled float can be used on many jobs.

Fig. 10-16. To produce a smooth, dense surface, finish with a steel trowel after the concrete has become quite stiff. (Portland Cement Association)

use a wood float for final finishing. Using a steel trowel would result in an oversmooth surface that would be slippery when wet.

Where a smooth surface is desired, as in a poultry-house floor, do the final finishing with a steel trowel. Avoid overtroweling, however, as this produces a surface that tends to check and dust off after hardening.

Where more than normal traction is desired, as on cattle walks or some pavements, finish the surface with a stiff broom.

9. PROTECTING FRESH CONCRETE WHILE CURING

Concrete needs moisture to cure and harden properly. New concrete, therefore, should be protected from drying out for at least 5 days. The common method of doing this is to cover floors and other

Fig. 10-17. A broomed finish makes a good nonslip surface where more than normal traction is desired, as on cattle walks. (Portland Cement Association)

horizontal surfaces with burlap, earth, straw, or some such material and keep it wet for the required time. Walls may be covered with burlap or canvas which is kept wet. Some protection may be afforded by leaving the forms in place.

A new method of curing, which appears to have real merit, is to spray on a curing solution. Such a solution, which may be bought from building-material dealers, consists essentially of a wax such as paraffin dissolved in a volatile oil or solvent. When such a solution is sprayed on a fresh concrete surface, the solvent vaporizes and leaves a thin film of wax on the surface. This wax seals the pores, keeping the water in and preventing the concrete from drying out too rapidly.

Concreting in cold weather New concrete should be protected from freezing for at least 3 days. If concrete work is done in freezing temperatures, heat the mixing water and the aggregate and protect the work after pouring by covering it with straw, manure, paper, or canvas, or by building enclosures around the new work and heating with stoves. Aggregate may be heated by building a fire inside an old smokestack, metal culvert, or steel barrel laid on its side and piling the aggregate over it. Cement should not be heated, nor should water hotter than 150°F be mixed with cement. Do not use materials which contain ice or frost, and do not deposit fresh concrete on frozen ground or in forms that contain ice or frost.

10. REMOVING FORMS

Forms should not be removed until the concrete has hardened sufficiently to be self-supporting and until there is no danger of damage to the concrete in removing the forms. The time will vary from 1 day to 2 weeks or more, depending upon the weather, the nature of the work, etc. In summer, wall forms may generally be removed after 1 or 2 days, and in colder weather in 4 to 7 days. Forms for roofs and floors over basements should not be removed in less than 7 days in summer and 14 days in cold weather.

If rough or honeycombed surfaces are found when the forms are removed, patch them by working a stiff cement mortar into the holes or crevices with a wood float. One part of cement and 2½ parts of sand makes a good mortar. It is better to avoid rough or honey-combed surfaces, however, by using a good workable mix and spading it well into the forms.

11. MAKING WATERTIGHT CONCRETE

Watertight concrete can be made by using a fairly rich, properly proportioned mix and doing a good job of mixing, placing, and curing. No special ingredients are required. Any of the mixes listed in Table 10-1, except the 1-2¾-4 mix, will make watertight concrete, if the work is carefully and properly done. It is particularly important that no more water be used in the mix than that specified in the table and that the concrete be kept moist for at least 7 days.

12. SETTING BOLTS IN CONCRETE THAT HAS HARDENED

It is often necessary to set bolts in concrete that has hardened, as when fastening motors or machines to concrete floors, or when setting stall partitions or other equipment to floors or walls. There are several ways to do this. One good way is to drill holes in the concrete and use expansion shields and lag screws. To use these, first drill holes of suitable size in the concrete, using a star drill and hammer or a special concrete-drilling bit in an electric drill. Then put the expansion shields in the holes, set the machine or object to be fastened down in place, and screw the lag screws into the holes. As they go in, they cause the shields to expand and lock themselves in the holes.

Another method is to drill holes in the concrete and set bolts, head down and sometimes with washers on them, in the holes, leaving the threaded ends to project the desired distance from the surface. The holes may then be filled with melted lead.

Still another method is to drill holes in concrete, fill them with melted lead, and then drill pilot holes in the lead to receive large wood screws or lag screws.

JOBS AND PROJECTS

1. Test two or three samples of sand for the presence of silt, using the fruit-jar or washing test.

2. Test samples also for the presence of harmful amounts of vegetable matter, using the lye-water test.

3. Using a ¼-in. screen, separate a sample of bank-run material into fine and coarse aggregate. Take a definite amount of material, such as a gallon, and measure the coarse and fine material in suitable measures, as pints. Does this sample of bank-run material have about the right proportions of coarse and fine material for average good farm concrete? (See Table 10-1 for trial mixtures.)

4. Examine samples of sand and of coarse aggregate for gradation or variation in size of particles. If suitable size screens are available, separate the samples into piles by screening, and then weigh or measure the amounts of material in each pile. If screens are not at

hand, simply spread the material out thin on a paper and note by inspection the amounts of fine, medium, and coarse particles. Refer to Figs. 10-1 and 10-2 for appearance of good samples.

5. Make a small trial mix of concrete that would be suitable for average farm work such as floors or steps. See Table 10-1 for suggested proportions. Decide upon just how much water should be used, and be careful to use no more than just this amount.
   Trowel the material thoroughly, and see if it makes a good workable mix that is smooth and plastic. Is it somewhat sticky when worked with the trowel? Is it somewhat "mushy" (not "soupy")? Does the material hang together reasonably well on the edges of the pile? (See Fig. 10-5 for the proper appearance of a workable mix.)
   If your trial mix is not satisfactory, just what should be done to make it better? Add the materials to change the batch, but do not change the proportions of water and cement.

6. How much cement, sand, and coarse aggregate will be needed for each of the following jobs?
   A drive 7 ft wide, 6 in. thick, and 150 ft long.
   A basement floor 4 in. thick, 30 ft wide, and 36 ft long.
   A foundation wall 8 in. thick and 30 in. high for a poultry house 20 ft wide and 30 ft long.

7. How many square feet of sidewalk 4 in. thick can be built with one sack of cement?

8. Make a list of a few improvements made of concrete that you would like to have about your home or farm, such as steps, walks, well curbs and platforms, and poultry-house or garage floors.
   Select one or two of these jobs that you think you could do, and make a list of cement, sand, and gravel, and also a list of form lumber that would be required. Estimate the costs.
   If arrangements can be made to do one or two of these jobs, plan the work carefully and do them.
   If it should not be feasible to do some concrete job as mentioned above as an individual project, it may be possible to do it as a class project. If so, each member of the class should help with the planning as well as the doing of the job, and when it is done, should make a short, well-organized report, outlining all steps of the job and including estimates of amounts of materials required, amounts actually used, costs, and so forth.

11 SOLDERING AND SHEET-METAL WORK

1. Operating a Gasoline Blowtorch
2. Cleaning Surfaces to Be Soldered
3. Applying Fluxes
4. Cleaning, Tinning, and Using Soldering Irons
5. Soldering Different Metals
6. Repairing Small Holes
7. Patching Large Holes
8. Soldering a Seam or Joint
9. Repairing Tubing
10. Soldering with Welding Equipment
11. Laying Out Sheet-metal Work
12. Cutting Sheet Metal
13. Folding and Forming Joints
14. Riveting Sheet Metal
15. Fastening Sheet Metal with Self-tapping Screws

SOLDERING is one of the most useful processes commonly done in the farm shop. Many valuable and timesaving appliances, as well as repairs, can be made with a very small outlay for materials and equipment. Soldering is really easy to do, but it is often not done well, because of failure to understand the process or careless methods of doing it.

When two pieces of metal are joined by soldering, the molten solder runs between them, fills up the spaces, and fuses with and penetrates into the surface of the pieces. Upon cooling, the solder solidifies and binds the pieces together. Soldering is essentially an alloying process, or

a process in which metals are fused and mixed together at the point of connection. It is therefore important that conditions be kept favorable for alloys to form while soldering. The two most important conditions are as follows:

1. The metals to be joined must be thoroughly cleaned of all grease, dirt, and oxide or tarnish and kept clean (usually with the aid of fluxes).
2. The pieces themselves must be heated and kept somewhat above the melting temperature of solder for a short time.

If the surfaces to be joined are dirty or coated with oxide, solder cannot alloy or mix with them. Likewise, if insufficient heat, or too much heat, is applied to the pieces, the solder will not alloy properly with the surfaces, and inferior work will result.

The solder most commonly used is composed of equal parts of lead and tin and has a melting temperature lower than that of either lead or tin. It is available in the form of bars, solid wire, or hollow wire filled with a flux core. For large jobs requiring considerable solder, it is usually more economical to buy it in bars. For the occasional job, acid-core or paste-core solder is convenient and satisfactory. Flux-core wire solders are more expensive than plain bar or wire solder, but where only a small amount of soldering is to be done, the added convenience of having the flux in the solder is well worth the extra cost.

1. OPERATING A GASOLINE BLOWTORCH

The gasoline blowtorch is useful not only for heating soldering irons and pieces being soldered, but also for many other jobs about the farm, such as heating a nut that is stuck, thawing a frozen pipe, or warming the intake pipe of an engine on a cold morning. The details of a blowtorch are shown in Fig. 11-1. Ordinarily untreated motor fuel may be used in a blowtorch, although stove or lamp gasoline is much superior and should be used whenever available. Ordinary motor fuel has a tendency to form gum and clog the small passages in the torch. Gasoline treated with lead should not be used because of its poisonous nature.

The torch is operated in the following manner.

1. Fill the fuel chamber about three-fourths full with clean gasoline through the filler plug in the bottom. Use only moderate pressure in

tightening the plug. If gasoline leaks around it, rub a little laundry soap on the threads.

2. Pump air into the chamber. Ten or twelve strokes of the pump will usually be enough if the pump is in good condition.
3. Fill the priming cup by opening the control valve a little and placing the thumb over the end of the burner to deflect the gasoline down

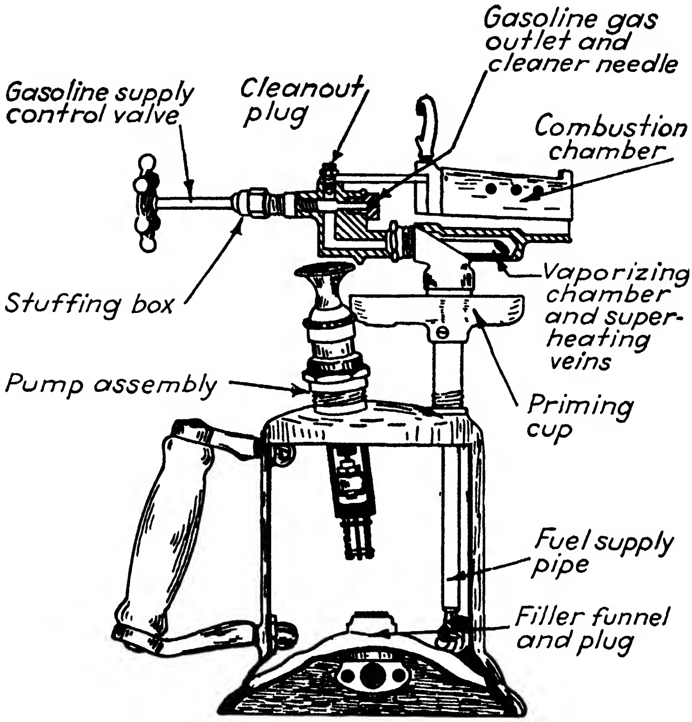


Fig. 11-1. Details of a gasoline blowtorch.

into the cup. Be careful not to let gasoline overflow onto the torch or bench. If it does, wipe it up thoroughly before lighting.

4. Light the gasoline in the priming cup, and protect the flame from any strong winds or drafts. It is essential that the burner be well heated to vaporize the gasoline.
5. Light the torch by opening the control valve just before the gasoline in the priming cup burns out. Do not open the valve too soon. Give the burner time to heat. If necessary use a match, applying it to the air holes in the side of the burner and not at the end of the burner.
6. To turn the torch out, turn the control valve just enough to stop the flow of gas, and no tighter. Screwing the valve too tight is likely

to damage the seat. The sheath around the needle valve will contract when the torch cools, forcing the valve very tight against its seat and possibly damaging the valve or the seat.

Remedying blowtorch troubles

Pump troubles If the pump fails to pump air, it is usually because of the drying out of the pump leather. In such a case, remove the pump plunger and oil the leather. It is a good plan to put a drop or two of oil on the leather occasionally to keep it soft and pliable. After the leather becomes worn, it should be replaced.

Another common cause of pump trouble is improper action of the check valve on the bottom of the pump. The valve is usually made of cork and is held against its seat by small springs. If the valve becomes cracked or if dirt prevents it from seating, the air in the torch will leak back through the pump and the plunger will not stay down. Sometimes a check valve will stick shut and not open to admit air from the pump to the fuel chamber.

In case of trouble with valve, remove the pump and examine the valve. If it is only dirty, simply clean it; if it is cracked, install a new piece of cork.

Gasoline leaks If gasoline leaks around threaded joints, unscrew them and apply common laundry soap to the threads. If leaks occur around the stuffing box of the control-valve stem, tighten the stuffing box nut *slightly* with a wrench.

Torch burns with pulsating red and blue flame If there is a strong pulsating flame, first red and then blue, the burner is not hot enough. The flame should be turned out, the priming cup refilled, and the torch regenerated. The cup probably cannot be filled from the torch itself, and gasoline will have to be supplied from some outside source, such as a squirt can. Sometimes a torch can be made to warm up by pointing the flame straight down against the ground. The burner is thus heated so that it can better vaporize the gasoline.

Torch burns with weak flame If the flame is weak and cannot be increased by opening the control valve further, then either (1) there is not enough air pressure in the chamber, or (2) the gasoline passages are partly clogged. Pump air into the chamber. If this does not remedy the trouble, then it can be assumed that the control-valve opening or some of the other gasoline passages are partly clogged. If a small particle of carbon or dirt is lodged in the control-valve opening, closing

the valve and then opening it two or three times will usually dislodge the particle.

If this fails to remedy the trouble, it is likely that the fuel-supply tube or some of the passages in the vaporizing chamber are clogged with dirt, gum, or carbon, especially if the torch is old or has been used a long time. Many torches have a cotton wick in the fuel-supply pipe to strain the gasoline and to prevent pulsation of the flame. After long use, the wicking may disintegrate or become clogged with dirt and have to be replaced.

If the passages are clogged, take the torch apart very carefully and clean it. Soaking the parts in kerosene or in alcohol will help to clean them. The passages may be blown out with compressed air or with a tire pump. Running small wires through the passages will sometimes help. Care must be used not to damage the small parts, particularly the control-valve orifice and the threaded plugs and openings. Coat all threads with laundry soap or a little commercial gasket compound before reassembling.

Manufacturers will ordinarily repair torches at reasonable cost if they are sent back to the factory. This may be more satisfactory than attempting to clean and repair them at home.

2. CLEANING SURFACES TO BE SOLDERED

Solder will not stick to metal that is dirty or coated with oxide or tarnish. The first step in soldering, therefore, is to clean the parts thoroughly and to remove all oxide or tarnish. This is commonly done by mechanical means, as scraping with a dull knife (see Fig. 11-2), filing, or rubbing with steel wool or emery cloth, or by the use of fluxes, or by the use of both mechanical means and fluxes.

Metals oxidize or tarnish to some extent when exposed to air even for short periods. When metal is heated as it must be in soldering, the oxidation takes place much more rapidly. A flux is therefore needed to remove the last trace of oxides just at the instant of soldering. A flux applied to a surface after cleaning and before heating helps exclude air and thus keeps the formation of oxides to a minimum.

A flux also fills the space between the soldering iron and the piece being soldered and thus better enables the heat to flow from the iron to the work. A flux, therefore, may be considered as aiding the soldering process in the following ways: (1) removing oxides, (2) preventing

or minimizing oxidation while the work is being heated, and (3) aiding the flow of heat from the soldering iron to the work.

Selecting fluxes Various materials in the form of pastes, liquids, or powders are used as soldering fluxes for different metals.

Soldering pastes under different trade names are available at hardware stores. They are compounded from various materials, and most of

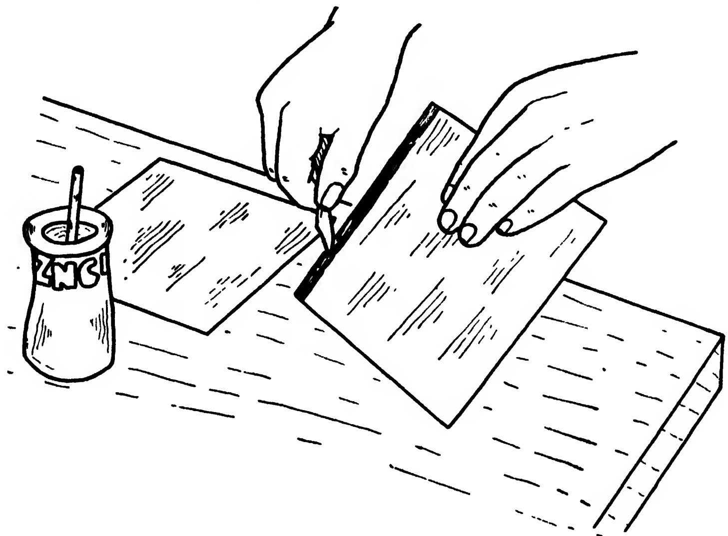


Fig. 11-2. One of the first steps in soldering is to clean the work thoroughly. This may be done by scraping with a dull knife.

them make excellent fluxes for most common metals. They are easily applied and are generally less messy and less corrosive than liquid fluxes.

Muriatic acid (commercial hydrochloric acid), when diluted with equal parts of water, is a very effective flux for soldering galvanized iron and zinc. It may be bought at drugstores. Because of its corrosive nature, muriatic acid must be used sparingly and with care. Muriatic acid may be used also as a cleaner for some metals like iron and steel, after which a suitable flux, such as zinc chloride, is applied. Muriatic acid may also be used to etch stainless steel before applying a flux.

Zinc chloride, or *cut acid,* as it is frequently called, is a common flux that can be used on most metals. It may be prepared as follows:

1. Drop small pieces of zinc into a bottle about half full of muriatic acid, adding more pieces from time to time until no more zinc will dissolve and there is a slight excess of zinc left in the bottle. The

resulting liquid is zinc chloride. Zinc may be obtained from an old fruit-jar lid or the shell of an old dry-cell battery. Zinc from such sources should be carefully cleaned before using.

2. After all chemical action has stopped, strain the zinc chloride through a cloth, or allow the dirt to settle and pour off the clear liquid.
3. Dilute the zinc chloride with one-fourth to one-half its volume of water.

Be careful not to get acid on the hands or clothing. *Do not keep acid or zinc chloride around tools;* and do not make zinc chloride around tools, as the vapors and fumes will cause severe corrosion. If acid or other flux should be spilled on tools, wipe it off at once, wash the tools with strong soap, rinse, and apply a coating of oil.

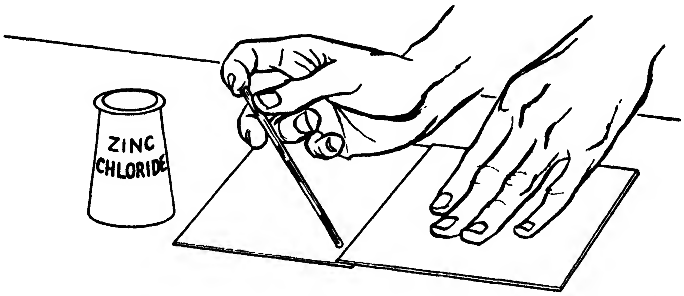


Fig. 11-3. After cleaning the work, apply flux. Liquid flux can be applied easily with a medicine dropper or a hollow glass tube.

Rosin is sometimes used for soldering bright tin. A small quantity of powdered rosin is sprinkled on the part to be soldered, and when the hot soldering iron is applied, it melts and spreads over the surface. Another method of using rosin is to dissolve it in alcohol or gasoline and apply it as a liquid. Rosin is a very mild flux. It is used where extreme caution must be taken against corrosion.

Tallow is a good flux for soldering lead. To use it, first scrape the lead to clean it; then heat it slightly and apply the tallow to the warm surface.

Sal ammoniac is a good flux for cleaning and tinning soldering irons. It may be obtained in cakes, in lumps, or in powdered form. A teaspoon of powdered sal ammoniac, or the equivalent in lump form, dissolved in a pint of water makes a good cleaning solution into which a hot soldering iron may be dipped quickly and only for an instant and thus cleaned.

Small cakes of sal ammoniac, especially prepared for cleaning and tinning irons, are available at hardware stores. These are quite satisfactory, and their use is generally recommended.

3. APPLYING FLUXES

Liquid fluxes may be easily applied with a medicine dropper or a hollow glass tube. To use a hollow glass tube, lower it down into the bottle of flux, and then place a finger tightly over the upper end. A small amount of flux is thereby trapped in the lower end of the tube and may be easily transferred to the work. To release the flux, simply remove the finger from the upper end of the tube (see Fig. 11-3). Small brushes may be used for applying fluxes that are not too corrosive.

Spread paste fluxes on the work with a small piece of wood, such as a matchstick, preferably after the work has been heated slightly.

Do not use more flux than necessary, and be careful not to get flux on parts that are not to be soldered, because many fluxes are corrosive, and all of them are somewhat messy.

4. CLEANING, TINNING, AND USING SOLDERING IRONS

Soldering irons are really made of copper, because of its resistance to oxidation and corrosion and because of its ability to absorb and give up heat readily. The best size of iron for average farm shopwork is the one that weighs about 1 lb. In general, the larger the iron that can be conveniently handled, the better. Large irons require heating less often. An iron that is too large, however, is clumsy and cannot be handled with ease.

Electric soldering irons are very convenient, as they heat quickly and enable soldering to be done on short notice. They are available in various sizes. An iron with a heating element of 100 to 200 watts is considered a good size for the farm shop. The better electric irons have removable copper tips.

Electric soldering guns are often used for soldering electrical connections or making repairs on delicate apparatus. They have small heating tips that heat almost instantly when the trigger is pulled.

By tinning an iron is meant simply coating the faces of the pointed

end with solder. Good work cannot be done unless the iron is kept well tinned. If the tinning becomes burned, then the iron cannot transfer heat readily from itself to the work being soldered. Also, an untinned iron is usually a dirty iron and is a hindrance to good work.

If the surface of an iron is pitted and rough from overheating, smooth it and clean it by filing, while either hot or cold (see Fig. 11-4).

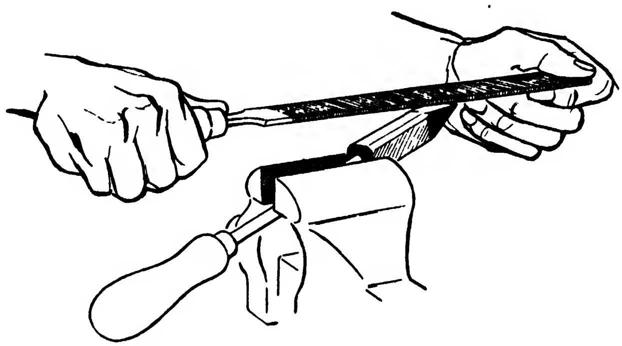


Fig. 11-4. A clean, well-tinned iron is essential. If the surface of the iron is pitted or rough from overheating, it may be smoothed and cleaned by filing while either hot or cold.

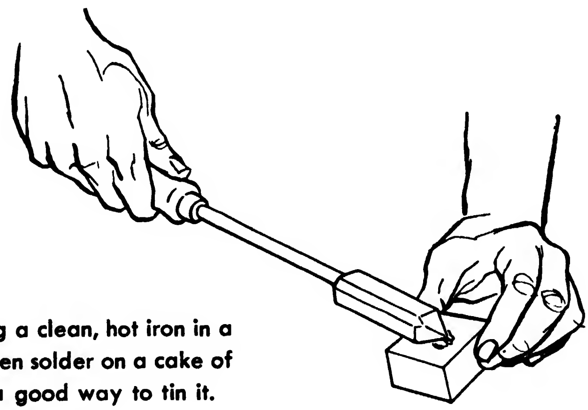


Fig. 11-5. Rubbing a clean, hot iron in a few drops of molten solder on a cake of sal ammoniac is a good way to tin it.

In extremely bad cases, hammer the end of the iron, while either hot or cold, to smooth and reshape the point. Be careful not to get the point too long or too short, but to retain the original shape.

After cleaning, tin the iron by heating and applying flux and solder. Probably the best way to do this is to rub the hot iron in 2 or 3 drops of molten solder on a cake of sal ammoniac (see Fig. 11-5).

Another way is to dip the hot iron quickly into and out of a cleaning fluid (which can be made by dissolving a teaspoon of sal ammoniac in a pint of water) and then rub it in molten solder.

Heating the soldering iron The gasoline blowtorch is quite satisfactory for heating soldering irons. It furnishes a clean, intense flame, and it can be readily taken to wherever it is needed. Any kind of heat that is reasonably clean, however, may be used for heating soldering

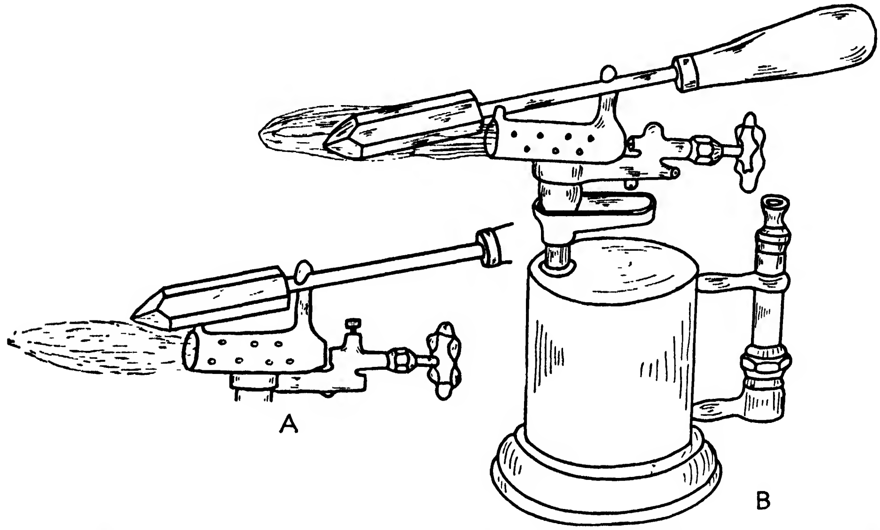


Fig. 11-6. The gasoline blowtorch is commonly used for heating soldering irons. Once an iron is heated, it may be kept at working temperature without overheating by pulling it back out of the flame, as at A. If the point of the iron changes from a silver to a yellowish color, it is too hot.

irons. Where gas is available, a small gas-heated bench furnace is ideal. Such a furnace may be easily made by mounting a burner from an old gas stove in a sheet-metal or firebrick enclosure on a metal stand.

To heat a soldering iron with a blowtorch, place the whole end of the iron—not just the tip—in the flame (see Fig. 11-6*B*). Once the iron is up to operating temperature, it may be pulled back out of the flame, as at *A,* Fig. 11-6, to prevent overheating and yet keep it hot.

Keeping the iron at proper working temperature A good workman is always careful to keep his iron *clean, well tinned, and at a good working temperature.* Only poor work can be done with an iron that

is too cold. The solder will melt and spread slowly and unevenly, and the work will be rough and lumpy rather than smooth and mirror-like. It will be difficult or impossible to heat the work up to the melting point of solder (and this is very important), and consequently a poor bond will form between the solder and the metal.

On the other hand, it is a common mistake of beginners to overheat the iron and burn off the tinning. In this condition, the iron is practically worthless for soldering, and it must be retinned. If the tinning begins to turn from a silverish to a yellowish color, it is getting too hot and should be removed from the flame or placed in a cooler part of the fire. The use of an overheated iron may burn some of the solder, or the zinc coating in the case of soldering galvanized iron, forming small particles of cinder or ash. These impurities will then be incorporated in the joint, making it weak and rough and marking it as the work of an inexperienced or careless workman. An iron

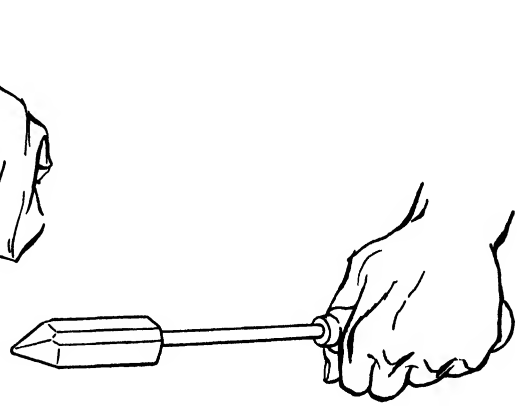


Fig. 11-7. Keep the iron clean while soldering by occasionally wiping it quickly with a clean damp cloth.

should therefore be heated until it will readily melt solder, but not until it is so hot that the bright tinning on the point begins to turn yellow.

A good way to judge the temperature of a soldering iron is to note the sound it makes when it is quickly dipped into a cleaning solution. If it is at the right temperature it will make a sharp snap or crack that is easily recognized; if too hot, a gurgling noise; and if too cold, very little or no noise.

Keeping soldering irons clean Soldering irons in use will continually become dirty and will require frequent cleaning, usually immediately after every heating. An iron may be cleaned while hot by (1) wiping it quickly with a damp rag (see Fig. 11-7), (2) dipping

it quickly and only for an instant into a cleaning fluid, or (3) rubbing it on a cake of sal ammoniac and then wiping it with a damp cloth.

Using the soldering iron The soldering iron is used primarily for two purposes: (1) to heat the metal being soldered up to soldering temperature and (2) to apply solder to the metal.

To heat the work quickly and easily, press the hot tinned iron *firmly* against it, being sure that both the iron and the work are clean

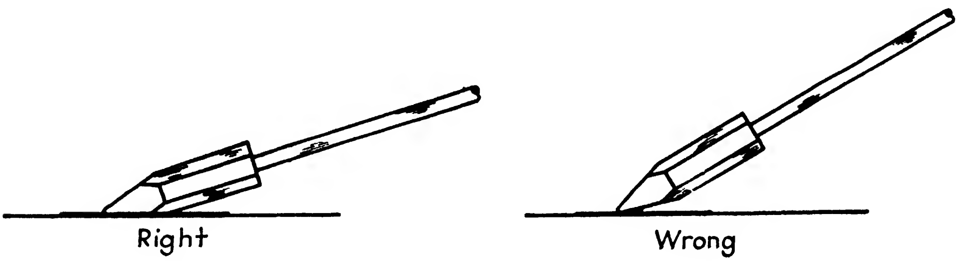


Fig. 11-8. Press the whole face of the soldering iron—not just the point—firmly against the work.

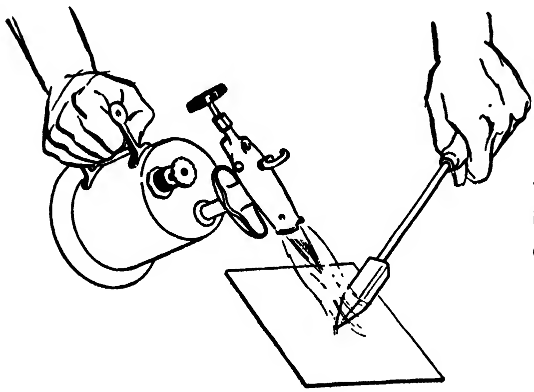


Fig. 11-9. Heat may be applied directly to the work while soldering. This method is especially good when soldering heavy or thick pieces.

and that a suitable flux has been applied. Hold the flat face of the iron—not just the point—against the metal being soldered (see Fig. 11-8). Move the iron *slowly* over the work, so as to allow time for the heat to flow from the iron to the metal. Heat may also be applied to the work by the direct flame of a torch (see Fig. 11-9). This method is especially good when working on large pieces.

Generally the best method of applying solder to small pieces is to pick it up on the iron, a drop or two at a time, and transfer it to the

work. To get the solder from a bar to the iron, allow the bar to project over the edge of the bench, or a block or brick on the bench, and bring the hot iron up against the end of the bar *from beneath,* melting one or two drops off onto the iron (see Fig. 11-10).

In soldering electric-wire splices, be sure to heat the wires until they are hot enough to melt solder. Do not try to flow solder onto cold wires. Have the soldering iron clean and well tinned, and hot enough to heat the wires quickly. If the iron is not hot enough, the wires will

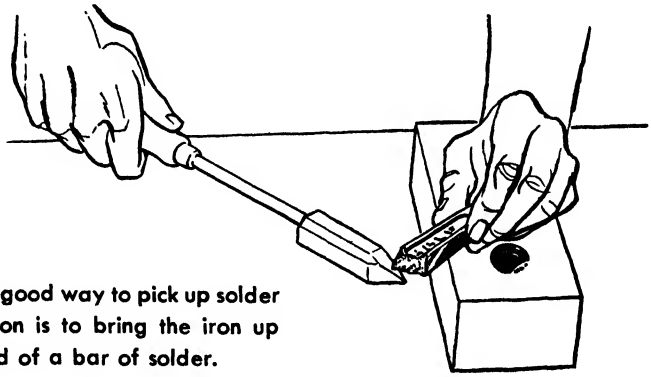


Fig. 11-10. A good way to pick up solder with a hot iron is to bring the iron up under the end of a bar of solder.

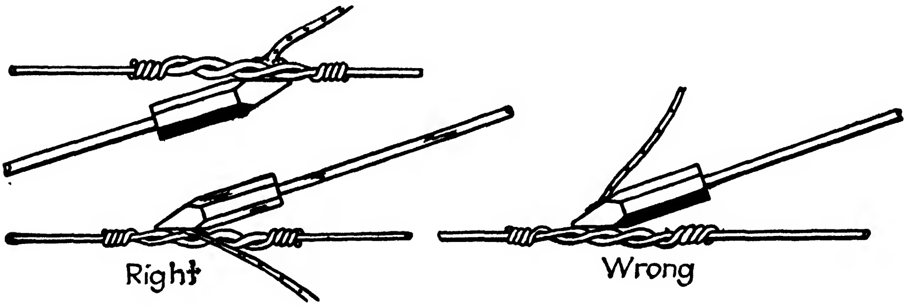


Fig. 11-11. In soldering wire splices, heat the wires until they are hot enough to melt solder. Do not drop hot solder onto cold wire.

heat slowly and the heat will flow out and heat the rubber insulation, possibly damaging it. The soldering iron may be placed under the splice or on top of it. In either case the iron should be used for heating the wires. The solder is applied to the heated wires.

Keeping the work clean After every application of the iron, give the solder a moment to cool, and then wipe the work with a damp rag to remove the dirt that always accumulates (see Fig. 11-12). If

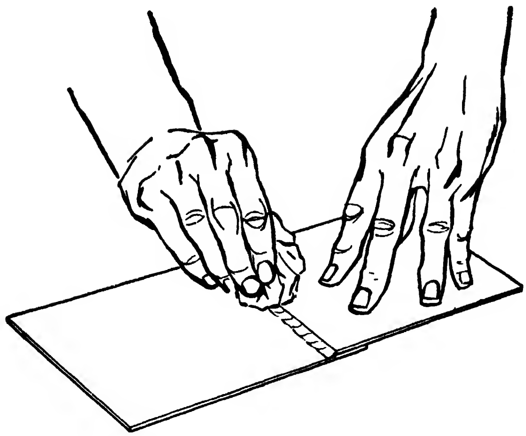


Fig. 11-12. Keep the work clean while soldering by wiping it frequently with a damp cloth. When the job is done, wipe off all excess flux to promote cleanliness and prevent corrosion.

the iron is to be applied again, then put another light coat of flux on the work. When the job is completed, wipe off all excess flux. This is especially important if acid or other corrosive flux has been used.

5. SOLDERING DIFFERENT METALS

Various metals respond differently to soldering operations. Some metals oxidize or tarnish more rapidly than others, or oxides may be more difficult to remove, thus requiring special fluxes or special methods for their removal. A flux that works well on one metal may not be suitable for another. Also, metals are affected differently by heat. To do good soldering, as pointed out previously, the work must be heated somewhat above the melting temperature of solder. Some metals, like lead, melt at low temperatures, and special care must be used not to melt them, yet they must be heated above the melting point of solder. Some metals are good conductors of heat and conduct the heat rapidly away from the soldering iron, making it difficult to get the surfaces being soldered above the melting point of solder. In such cases, it is advisable to use a large soldering iron and to heat it as hot as possible without burning the tinning on the point, and possibly also to apply heat direct from a torch or some other means.

Soldering tin plate The metal usually called "tin," such as is used in "tin" cans, is really tin-plated iron or steel sheet. It is the tin coating that must be considered, however, when soldering it. Tin-

plated iron or steel is very easy to solder. Several different fluxes work well on it. Commercial soldering pastes are usually quite effective and may be less corrosive than zinc chloride. If it is important that no corrosion take place, use rosin as a flux. It may be sprinkled on the parts to be soldered and then melted with the soldering iron, or a little may be dissolved in gasoline or alcohol and then applied with a small brush or swab.

Use a clean, well-tinned soldering iron. Be careful not to heat the metal so hot as to burn off the tin plating. The metal is usually thin, and it heats easily and rapidly. Apply flux sparingly and only to those parts to be soldered. Flow the solder well into the joint or seam, and do not pile it up on the outside. After the work has cooled, wipe it with a damp rag to remove dirt and excess flux.

Soldering zinc and galvanized iron Galvanized iron is zinc-coated iron. The best flux for soldering zinc and zinc-coated metals is muriatic acid, or raw acid, diluted with about equal parts of water. The muriatic acid acts with the zinc and forms zinc chloride. The melting temperature of zinc is rather low, and it is therefore important not to use a soldering iron so hot as to melt or burn the zinc. If too hot an iron is used, the zinc will burn and leave the work rough and grainy. In case the zinc coating becomes burned and the work is rough and grainy, melt the solder with a well-heated soldering iron and then quickly wipe the joint with a damp rag. Then reflux and proceed with soldering. Since muriatic acid and zinc chloride are corrosive, be sure to wipe off any excess flux when the job is done. It may be advisable to wash the parts with laundry soap, and then rinse and dry.

Soldering copper and copper alloys Copper and brass and most other copper alloys are easy to solder. Zinc chloride is probably the best flux, although most commercial soldering pastes work well and may be less corrosive and messy to use. Copper and copper alloys conduct heat very readily, and therefore may be a little difficult to heat to proper soldering temperatures. This being the case, it is important to use a hot, well-tinned soldering iron, to press it firmly against the work, and to move it along slowly. A large iron is usually better than a small one. In some cases, it works well to apply heat direct to the work with a torch. As in all soldering, keep the work clean, apply flux only to those parts to be soldered, flow the solder well into the joints, and wash or wipe off excess flux when the job is done.

Soldering lead To solder lead, first remove the oxide or tarnish by scraping with a knife or scraper, leaving the surfaces to be soldered perfectly bright. Tallow, rosin, zinc chloride, or soldering paste may be used for flux. Apply the flux immediately after scrapping. Since lead melts at a very low temperature, be careful not to melt in with the hot soldering iron. Heat the iron just enough to melt solder readily, and then do not hold it in contact with the lead too long at a time. The secret of success in soldering lead is to control the heating, raising the temperature of the lead parts above the melting point of solder, but not to the melting point of lead.

Soldering iron or steel The first step in soldering iron or steel is to thoroughly remove the oxide or scale from the surfaces to be joined. This may be done by grinding, filing, or scraping. Sometimes it helps to apply muriatic acid after filing, grinding, or scraping. After the surfaces are thoroughly cleaned, apply zinc chloride and tin them. Use a soldering iron that is well heated. On large pieces, a torch may be used also. After the surfaces are tinned, solder the parts much the same as with other metals.

Soldering stainless steel Since stainless steel resists corrosion, it also resists the action of fluxes. For this reason, it is recommended that the surfaces of stainless steel parts to be soldered be first etched with muriatic acid. Apply the acid with a small brush or swab, being careful to get it on only those parts to be soldered. If by accident acid is applied to other parts, wash it off with laundry soap and rinse it. After etching, wipe off the acid with a damp rag and apply zinc chloride for flux. Soldering is then completed much the same as for other metals. Wash off excess flux when the work is finished.

Soldering aluminum and aluminum alloys Aluminum and aluminum alloys conduct heat away rapidly and also oxidize rapidly. They are therefore difficult to solder. Once such a metal is tinned, however, it can be soldered much the same as other metals except that no flux is used. To tin aluminum or aluminum alloy, heat it with a torch or other means until it will melt solder. Then brush it vigorously with a wire brush in the presence of molten solder. This may have to be repeated several times, being careful not to overheat and burn parts already tinned. Another way recommended for tinning aluminum is to

heat it, then melt some solder onto it, and then rub back and forth with a clean, hot soldering iron. Before the solder solidifies, wipe it off quickly with a small piece of steel wool. Apply more solder and continue to rub with the iron, being sure the iron stays clean and hot.

Special aluminum solders and fluxes are on the market and are usually available in small packages with direction for use. For the occasional repair job, it is probably best to buy some such solder from a reputable company and then carefully follow directions for its use.

6. REPAIRING SMALL HOLES

To repair a small hole in sheet metal, first thoroughly clean the metal around the hole, on both the top and bottom sides where practical. Then apply a suitable flux, usually a paste flux, except on galvanized surfaces, which are best treated with muriatic acid.

Next apply a drop of solder to the hole, using a clean, well-tinned, hot soldering iron. Use firm pressure on the iron, and move it about slowly so as to thoroughly heat the metal around the hole. Sometimes it works well to put the point of the iron straight down into the hole and rotate it back and forth slowly (see Fig. 11-13).

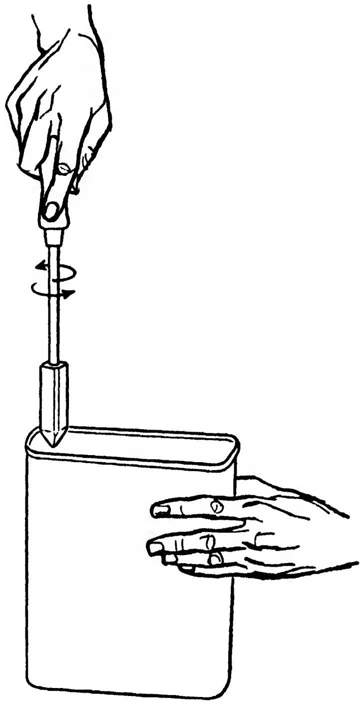


Fig. 11-13. A small hole may be soldered by cleaning and fluxing and then rotating a well-tinned, hot iron back and forth slowly with the point in the hole.

When the solder is thoroughly melted and spread out evenly around the hole, remove the iron and allow the solder to cool.

Turn the work over, if possible, and inspect the other side. If the solder has not spread out evenly and smoothly around the hole, wipe with a damp cloth, place a little flux around the hole, and then apply a clean, well-tinned, hot iron. After the job is done, wipe it with a damp cloth to clean it and remove any excess flux.

Repairing a hole with a rivet and solder A hole that is slightly too large to be stopped with a drop of solder may be plugged with

a rivet, and then solder can be applied over the rivet (see Fig. 11-14). To make such a repair, first clean thoroughly around the hole, and then insert a short copper or galvanized rivet and hammer it down. Do not use a long rivet. If necessary, cut it off. The rivet, of course, should be clean.

Fig. 11-14. An effective way of repairing a medium-sized hole is to clean the metal around the hole, insert a rivet, and then apply solder.

Next apply a suitable flux, and flow solder over the rivet and around the hole, using a clean, well-tinned, hot iron. Solder both the top and bottom sides of the hole. With careful work, a smooth, neat job results.

7. PATCHING LARGE HOLES

A hole too large to be stopped with a rivet may be repaired by sweating a patch of metal over it. To make such a repair, first clean the metal around the hole, flux it, and coat it with solder. Likewise, clean the patch itself, and then flux it and coat it with solder. Be sure to keep the work clean, wiping with a damp cloth between heats as may be required.

Place the patch over the hole, apply flux, and then heat with a clean, well-tinned, hot iron. When the solder is well melted, hold the patch in place with the tang of an old file, or a piece of scrap iron or wood, until the solder cools. *Never use a tempered tool, like a screw driver or an awl, for this purpose,* as the heat will draw the temper. Also, the flux will likely cause the tool to rust.

It may be necessary to add a little solder around the edges of the patch to make a smooth job. In this case, be careful not to melt the whole patch loose. Use a well-tinned, hot iron, and do not hold it in one place too long. Work fast, taking first one edge of the patch and then the other. In this way, there is less danger of melting the patch loose.

It is always a good plan to solder both the inside and the outside of the patch whenever possible, so as to make a smooth, neat job. This requires careful work to avoid melting the patch loose. The main precautions are to use a clean, well-tinned, hot iron—possibly a little hotter than for average work—and to work rapidly. If the iron is left in contact with the work too long, there is a tendency for heat to spread too far, possibly melting the patch loose.

8. SOLDERING A SEAM OR JOINT

To solder two pieces together with a plain lap joint, first clean the parts to be joined, and apply a suitable flux. Next, put the pieces together and "tack" them in place with a drop of solder at intervals along the seam (see Fig. 11-15). Move a clean, hot iron along, keeping

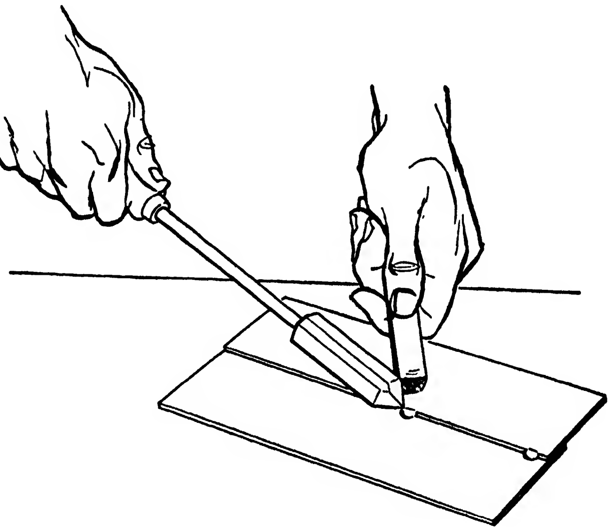


Fig. 11-15. In soldering a lap joint, it is best first to "tack" the pieces at intervals and then solder the remainder of the seam.

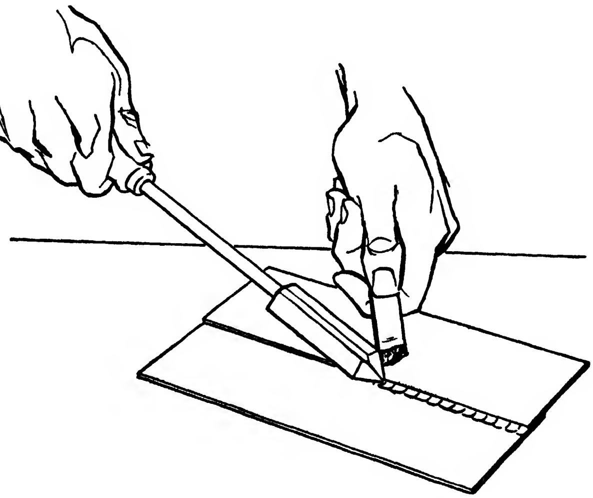


Fig. 11-16. Soldering a lap joint after "tacking." When considerable solder is required, hold the end of the bar against the point of the iron as it is drawn along slowly over the work.

it pressed firmly against the work, and feed solder into the seam by touching it to the iron (see Fig. 11-16). If there is a tendency for the pieces to melt apart, hold them together with the end of an old file or a piece of scrap iron while the solder cools.

9. REPAIRING TUBING

A leaky metal tube, such as a fuel or oil line on an engine, can usually be repaired by soldering. If the hole is small, simply file, scrape, or otherwise clean the metal around the hole, apply flux, and then solder it. Copper and brass tubes are very easily soldered.

If there is a large crack in the tube, it may be advisable to reinforce the joint by wrapping a piece of sheet metal snugly around the break and then soldering it in place. Another method that is often effective is to wrap copper or brass wire tightly and closely around the tube a short distance each way from the hole, and then solder it in place (see Fig. 11-17). It is necessary, of course, first to clean the tube thoroughly and tin it before wrapping either with sheet metal or with wire. The sheet metal or wire must also be clean. Be sure to flow the solder evenly and smoothly over the whole wrapping.

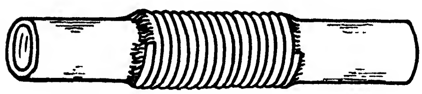


Fig. 11-17. A leak in a tube may be repaired easily by (1) cleaning, fluxing, and tinning; (2) wrapping tightly with clean wire; and (3) applying solder over the wire.

10. SOLDERING WITH WELDING EQUIPMENT

Soldering can be done with either oxyacetylene or electric-arc welding equipment, although it is somewhat difficult, particularly when working on thin metal or small parts. Welding equipment generates much more heat than is necessary for soldering, and it is difficult to regulate or control the heat so as to avoid burning the work. Soldering with welding equipment is no different from soldering with other kinds of heat so far as general principles are concerned. It is necessary to clean and flux the metals the same as when other sources of heat are used.

Soldering with the oxyacetylene torch In soldering with the oxyacetylene torch, first carefully clean and flux the parts, and then

select the smallest tip and put it on the torch. Light the torch and adjust it for a small, soft, neutral flame. Hold the torch back so that only the very tip of the flame touches the work, and play it about to heat the work evenly. If the work heats too rapidly, remove the torch for an instant, or point it at an angle instead of directly toward the work. When the work is heated, touch the end of a piece of wire solder to the surface. If the heating has been carefully done and the parts properly cleaned and fluxed, the solder will flow out in a thin, even film. As soon as the work cools, wipe it with a damp rag to remove dirt and any excess flux.

Soldering with electric arc welding equipment There are two methods of using electric arc welding equipment for soldering. Probably the best method is to set the welder for a current of 20 to 30 amp (amperes) and use a single carbon electrode about 3/16 in. in diameter. Keep the carbon sharpened to a round conical point, or to a blunt chisel-shaped point. Hold the carbon directly in contact with the work and draw it along. Current flowing through the metal and across the contact between the carbon electrode and the metal quickly heats it to the soldering temperature. Solder can then be melted and flowed onto the surface if it has previously been cleaned and fluxed.

The carbon arc torch may also be used for soldering. Use small-size carbons not over 3/16 in. in diameter and set the welder for a current of 20 to 30 amp. Adjust the arc torch to give a quiet, soft flame. Be sure to have the helmet or hand shield in place before starting the arc. Keep the flame back from the work a short distance and move the torch back and forth to gradually heat the area to be soldered. When it has reached the soldering temperature, bring the end of the wire solder down into contact with the surface. If the cleaning, fluxing, and heating have been properly done, the solder will melt and flow out evenly over the surface.

Soldering with the air-acetylene torch The air-acetylene torch, which burns acetylene mixed with air, gives a soft flame that is much easier to use for soldering than either the oxyacetylene flame or heat from arc welding equipment. Where much soldering or silver brazing is to be done, it may be advisable to purchase an air-acetylene torch.

Using other sources of heat for soldering Any source of heat which is clean and of suitable intensity and which can be readily controlled

can be used for soldering. With the increase in the use of liquefied petroleum gas on farms, this fuel may in some cases be used satisfactorily in gas burners to heat soldering irons, or in a small torch similar to the air-acetylene torch.

Small containers of liquified petroleum gas for use with small hand torches (see Fig. 11-18) are sometimes available and are very convenient for soldering, particularly on lightweight metal. To light such torches, simply hold a lighted match at the nozzle and open the valve a

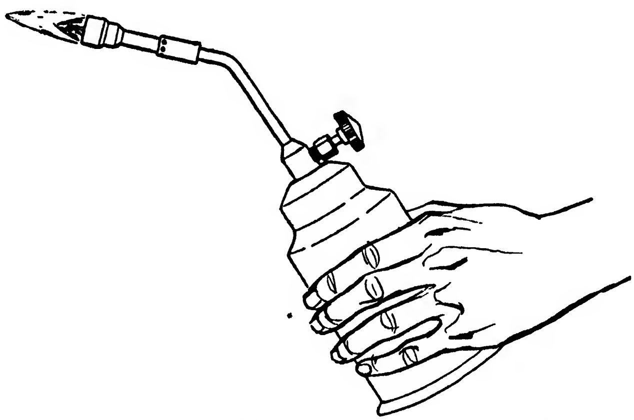


Fig. 11-18. A small hand torch attached to a small container of liquefied petroleum fuel is very convenient for occasional small soldering and heating jobs. When the container is empty, it is discarded and a new full one attached to the torch.

part turn. When all the fuel is used from the container, it is simply discarded and a new full container attached to the torch. Such torches, while not particularly suited for continuous heavy-duty work, are very convenient for occasional small jobs.

Points on soldering

1. Thoroughly clean all parts to be soldered.
2. Use a suitable flux.
3. Heat parts being soldered somewhat above the melting point of solder.
4. Be sure the soldering iron is clean, well tinned, and properly heated.
5. A general-purpose soldering paste is an excellent flux for most common metals.
6. Zinc chloride, or cut acid, is a good flux for most metals.
7. Muriatic acid is a good flux for soldering zinc and galvanized iron.

8. Wipe off excess flux when the soldering is done. Many fluxes are corrosive.
9. A good way to tin an iron is to heat it and then rub it in 2 or 3 drops of molten solder on a cake of sal ammoniac.
10. A soldering iron may be cleaned by wiping it while hot with a damp rag, or by dipping it quickly and for just an instant into a cleaning solution or dip.
11. A teaspoon of powdered sal ammoniac dissolved in a pint of water makes a good cleaning solution or dip for soldering irons.
12. Keep the iron at a good working temperature. If it is too cold, it will not readily melt solder. If it becomes overheated, the tinning will be burned from the point.
13. If the bright tinning on the point of an iron begins to turn yellow, it is getting too hot.
14. An iron at a good working temperature makes a sharp snap or crack when it is dipped into a cleaning solution. An iron that is too cold makes very little or no noise; an iron that is too hot makes a gurgling noise.
15. Hold the iron firmly in contact with the parts to be soldered to make it easier for the heat to flow from the iron to the work.
16. Move the iron slowly over the work, advancing it along the seam or joint as the solder melts.
17. To melt solder from a bar onto the iron, allow the end of the bar to project over the edge of a brick on the bench, and bring the iron up against the end of the bar from beneath.
18. As soon as the solder cools, wipe the work with a damp rag to remove the dirt which accumulates.
19. Take precautions against accidental fires when filling and operating a blowtorch.
20. In turning out a blowtorch, turn the control valve just tight enough to stop the flow of gas. Screwing it too tight may damage the valve seat or needle.
21. Keep fluxes away from tools.

11. LAYING OUT SHEET-METAL WORK

In making appliances of sheet metal, it is very important first to mark out the pattern accurately on the metal, so that it may be cut and bent properly. Marking is best done with a sharp-pointed instru-

ment such as an old saw file that has been ground to a needle point on the end, or an awl. A pencil makes a line that is too wide and indistinct. Also, it is easily erased or smeared by handling. Mark circles and arcs with dividers.

Always use a square to ensure accurate marking of lines at right angles. In marking out patterns for many appliances, it is best first to lay out two base lines at right angles to each other and to do all measuring and squaring from these; or to straighten one edge of the stock and square one end with it, and then use this edge and this end at base lines.

12. CUTTING SHEET METAL

The best tool for the average job of sheet-metal cutting is a pair of tinner's snips (see Fig. 11-19). These tools are made in various styles, as straight snips, curved snips, or hawk-bill snips. The straight snips are used for straight cutting and for cutting on outside curves. They are quite adequate for most farm shopwork. Curved snips and hawk-bill snips are used for cutting inside curves and in close quarters where straight snips would be awkward or difficult to use. For an occasional job of cutting light sheet metal, even a pair of old scissors may be used.

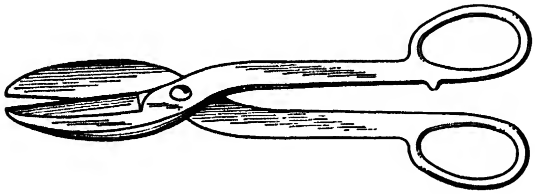


Fig. 11-19. Tinner's snips.

Using the snips To use a pair of snips for straight cutting, open the blades wide and insert the sheet metal all the way back in the throat. Be sure the cutting edge of the upper blade is exactly over the line of cutting, and then squeeze the handles together. It is best not to cut all the way out to the tips of the blades, but to stop and take a new cut. This avoids small nicks and burrs made by the ends of the blades when full-length cuts are made.

When cutting a large sheet, allow the right part to bend down somewhat and pull the left part up a little to allow room for the hand to operate the snips (see Fig. 11-20). When trimming the edge of a sheet, allow the part trimmed off to curl or roll up (see Fig. 11-21). Always be careful to keep the cutting edge of the top blade directly over the line to be cut.

When cutting a short distance into the edge of a piece of metal, as in cutting notches, it is usually best to open the blades only a little, allowing the metal to go back between the blades just the distance to be cut, and then to do the cutting with the tips of the blades (see Fig. 11-22). When cutting is done well back on the blades, it may not be possible to stop the cut at exactly the point desired.

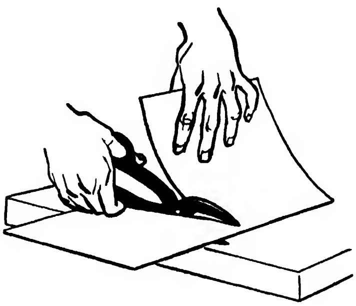


Fig. 11-20. Straight cutting with tinner's snips. Keep the cutting edge of the upper blade exactly over the line to be cut.

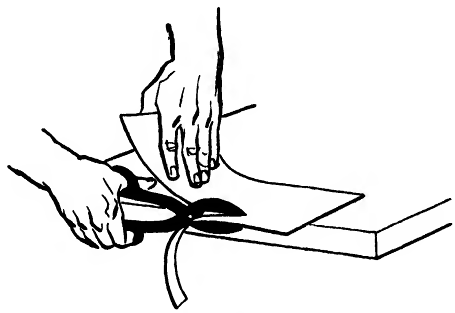


Fig. 11-21. Trimming the edge of a piece of sheet metal.

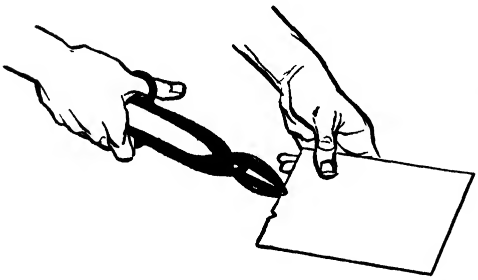


Fig. 11-22. When cutting small notches with tinner's snips, use only the tip ends of the blades.

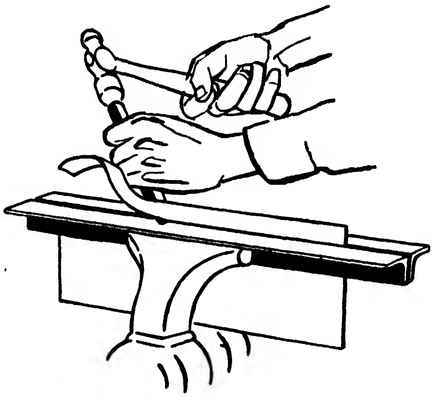


Fig. 11-23. A good way to cut heavy sheet metal with a cold chisel. Use a sharp chisel and keep the bevel of the chisel flat against the angle iron (see also Fig. 12-5).

Cutting heavy sheet metal Heavy sheet metal may be cut by clamping it in a vise, or between bars or angle irons held in a vise, and then shearing it with a cold chisel (see Fig. 11-23). In cutting sheet metal in this manner, the following points are important:

1. Clamp the metal with the line of cutting just even with the top of the vise jaws (or the bars or angle irons held in the vise).
2. Keep the bevel of the cold chisel flat against the vise jaw or the bar.
3. Hold the chisel to one side to give an angling shear cut.
4. Use a sharp chisel. It may be advisable to grind the cutting edge keener than for average cutting with a cold chisel.

This same method may be used for cutting thin sheet metal also, but it is difficult to make a smooth, even cut with a cold chisel if the metal is too thin.

13. FOLDING AND FORMING JOINTS

Frequently a hook or lock joint, as illustrated in Fig. 11-24, can be used to advantage in making appliances of sheet metal. The joint is strong and easily made and gives a neat, finished appearance to a piece of work.

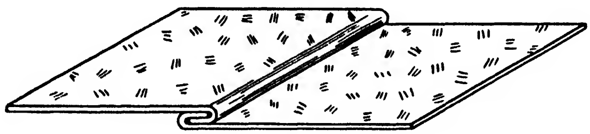
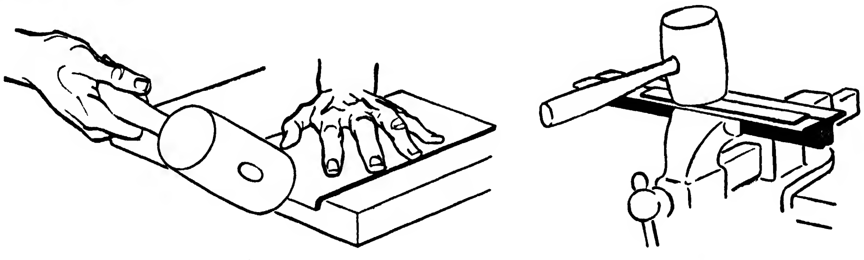


Fig. 11-24. The hook joint is a good method of joining pieces of sheet metal. It is strong and it is easily soldered.



A B

Fig. 11-25. Two good ways of starting the bends for the hook joint. Extend the metal over the edge of the bench and bend with a hammer or mallet as at *A*; or clamp the metal between irons in a vise and bend as at *B*.

To start such a joint, extend the edge of the metal over the edge of the bench and bend it down with a hammer or a mallet (see Fig. 11-25*A*); or clamp the metal in a vise or between bars in a vise and bend it (see Fig. 11-25*B*). The metal may also be bent over the edge of an anvil or over a bar of iron or a piece of hard wood clamped

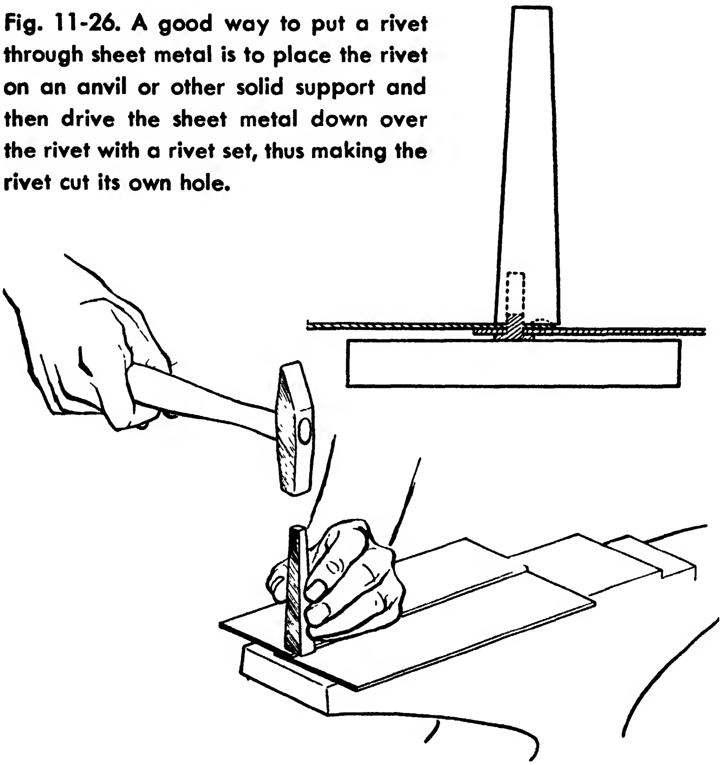
in a vise. After the edges of the two pieces to be joined are bent down about square, bend them on farther back, forming hooked edges. Then hook the two pieces together, and hammer the joint tight with a mallet or a hammer. The joint is then ready to be cleaned and fluxed if it is to be soldered.

In hammering sheet metal with a hammer, be careful not to stretch or deform the metal with heavy blows. A wooden mallet is usually better than a hammer, because there is less danger of beating the metal out of shape.

14. RIVETING SHEET METAL

Riveting can often be done to advantage in repairing and making sheet-metal appliances. A good way to rivet two pieces of sheet metal

Fig. 11-26. A good way to put a rivet through sheet metal is to place the rivet on an anvil or other solid support and then drive the sheet metal down over the rivet with a rivet set, thus making the rivet cut its own hole.



together is as follows: Place a rivet on an anvil or other solid support such as a bar held in a heavy vise, and then drive the pieces of sheet metal down over the rivet with a tool called a *rivet set*. The rivet thus cuts its own hole (see Fig. 11-26). A rivet set is essentially a small bar

of steel with a hole drilled up into it to receive the end of the rivets and with a cup-shaped depression for use in forming rounded heads on rivets.

After a rivet is in place in the hole, hammer down the end and form a head on it. Use a few straight medium-weight hammer blows (see

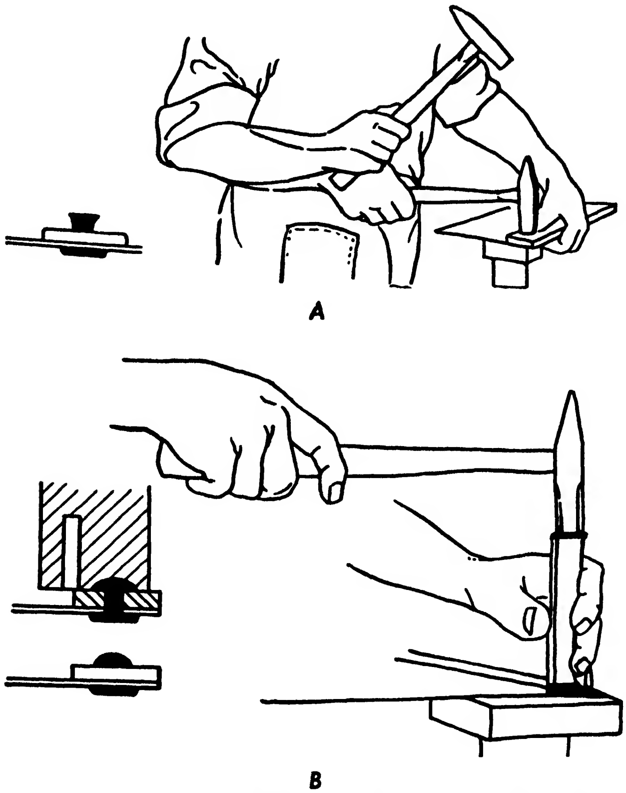


Fig. 11-27. A, in hammering down the end of the rivet, strike a few straight, medium-weight blows. Heavy blows or too many blows will cause the metal to stretch and buckle around the rivet. B, finish the job with the cuplike hollow in the rivet set. (Stanley Tools)

Fig. 11-27*A*). Heavy blows or too many blows will cause the metal to stretch and buckle around the rivet. If a rivet starts to bend, cut it off, remove it, and insert a new one. Finish the job of heading the rivet with the cuplike hollow in the rivet set if a neat appearance is important (see Fig. 11-27*B*).

Holes for rivets in sheet metal may be punched or drilled. Where extreme accuracy is necessary, marking with a center punch and then

drilling or punching is better than making rivets cut their own holes. A good way to punch holes in sheet metal is to use a solid punch over end-grain wood or over a block of lead.

15. FASTENING SHEET METAL WITH SELF-TAPPING SCREWS

A good way to fasten pieces of sheet metal together is to place the pieces together, make a small hole with an awl or sharp-pointed tool, and then insert a sharp-pointed self-tapping sheet-metal screw. Such a screw (see Fig. 11-28) will enlarge the hole slightly and cut threads in it as it is driven up with a screw driver. Screws of this type are available at tinners' shops and hardware stores.

Fig. 11-28. Sheet-metal screws are often used for fastening sheet-metal parts together.

This method of fastening is not so tight and secure as riveting, but is much faster and easier, and for many jobs it is entirely satisfactory. It is particularly good for fastening joints of sheet-metal pipe, like stovepipe, together. Pieces fastened with these screws are easily taken apart.

JOBS AND PROJECTS

1. Fill, generate, and light a blowtorch; then heat and tin a soldering iron.

2. Cut small pieces of metal and practice soldering on them. Stop a few nail holes with solder, leaving a smooth surface on both sides of the metal. Also stop a hole with a rivet soldered in place, and sweat a patch over a larger hole. Practice making both plain lap joints and hook joints.

   After you have practiced repairing different sizes of holes, making joints, and so forth, cut some other pieces of metal neatly to size and make samples of work. The work outlined in the following drawing is suggestive.

3. Clean and tin a small piece of copper tubing, wrap it tightly with *clean* wire for a distance of about ½ in., and then solder the wrapping in place.

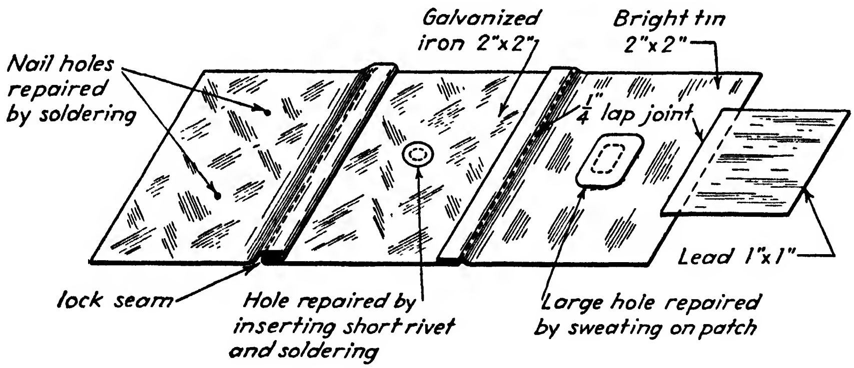
4. Look through shop manuals, books, bulletins, etc., and make a list of small appliances made of sheet metal that you could make in the shop.

   Select one or two of these that you could use at home and that would give you valuable experience in working and soldering sheet metal, and make them. If the available designs or plans could be modified slightly to suit your needs better, make such changes.

5. A check list of small appliances made of sheet metal includes

Small pan	Lamp shade
Funnel	Book ends
Feed scoop	Dustpan

6. From around your home gather up articles made of sheet metal, such as pails, chick water fountains, funnels, and oil cans, that need repairing. Take them to the shop, clean them thoroughly, solder all holes or leaks, and do such other repairing as may be needed to put them in good serviceable condition.



12 COLD-METAL WORK

1. Distinguishing between Different Kinds of Iron and Steel
2. Laying Out and Marking Metal
3. Cutting with a Cold Chisel
4. Filing
5. Hack Sawing
6. Selecting Drilling Equipment
7. Drilling Holes in Metal
8. Bending Cold Metal
9. Riveting
10. Threading

COLD-METAL work constitutes one of the most important phases of farm shopwork. Most farm machines and many small appliances used on the farm are made of metal. Many valuable repair jobs can be done with the use of only a few simple hand tools, such as a vise, a hack saw, a hammer, cold chisels and punches, and a few files, drills, and threading tools. Every farm shop should have a fair assortment of such tools.

1. DISTINGUISHING BETWEEN DIFFERENT KINDS OF IRON AND STEEL

There are many different kinds of iron and steel which have different uses and properties. The mechanic who works with iron and steel should, therefore, be able to distinguish between these different kinds and know something of their different properties so that he can use the best methods of cutting, filing, shaping, etc. A knowledge of the different kinds of steel and iron is also essential for effective work in forging, tempering, and welding.

Pig iron The first step in the manufacture of iron and steel is to extract the iron from the iron ore, which is mined in various parts of the world. This is done by means of the modern blast furnace. The molten iron accumulates at the bottom of the furnace and is drawn off and taken to other furnaces for further refining, or it is cast into short thick bars known as *pig iron*. Pig iron is then used as the source from which other kinds of iron and steel are made.

Cast iron To make castings, the pig iron is remelted, together with small amounts of scrap steel and iron, and poured into molds of the desired shape and then allowed to cool and solidify. Cast iron is used extensively because it is cheap and can be readily molded into complicated shapes. It is hard and brittle and cannot be bent. It cannot be forged or welded in the forge, but it can be welded with the electric arc welder or with the oxyacetylene torch. It crumbles when it is heated to a white heat in the forge. It can be drilled and sawed easily and also filed easily after the hard outer shell is removed. Cast iron has a rather coarse-grained texture.

Chilled iron Chilled iron is cast iron that has been made in special molds, sometimes water-cooled molds, that cool the outer portions of the casting rapidly, thus making the surface of the casting very hard and wear-resistant. Chilled iron is used for bearings on many farm machines and for shares and moldboards of plows designed for use in sandy, gravelly, or rocky soils.

Malleable iron Malleable iron is cast iron that has been treated after casting by heating for a long period. This prolonged heating changes or transforms some of the carbon in the outer portions of the casting and reduces its brittleness. Malleable castings are softer and tougher than plain castings and can be bent a certain amount without breaking. They are also more shock-resistant. One of the most practical ways of repairing malleable castings is by braze welding (see pages 541 to 547).

Wrought iron Wrought iron is practically pure iron with a small amount of carbon and slag mixed with it. It is made from pig iron. It is fibrous or stringy rather than grainy. It is easily bent, cut, shaped, and welded. It cannot be hardened or tempered.

Mild steel Mild steel, also known variously as ***machine steel, low-carbon steel, soft steel,*** and ***blacksmith iron,*** contains about 0.1 to 0.3 percent carbon. It cannot be hardened appreciably. It can be bent and hammered cold to some extent, and it can be easily sawed, filed, or ground. It can be forged and welded in the forge, but it is a little more difficult to weld than wrought iron. It is easily welded with the oxyacetylene torch or the electric arc welder. It is the kind of steel most commonly used in the farm shop for repair of farm machinery and equipment and the construction of appliances made of steel. It is available in bars and rods and also as angle irons of various sizes.

Tool steel Tool steel is made from pig iron, usually by refining in the electric furnace. It is practically free from impurities and contains about 0.5 to 1.5 percent carbon. The higher the percentage of carbon, the more the steel may be hardened, and the more difficult it is to weld. Tools like hammers and cold chisels are commonly made of steel having 0.5 to 0.9 percent carbon. Tools like taps and dies are made from steel that contains 1 to 1.25 percent carbon. The carbon content of steel is designated by points, one point being one-hundredth of 1 percent of carbon. Thus a 50-point carbon steel contains $^{50}/_{100}$, or one-half, of 1 percent of carbon. Tool steel is fine-grained in texture rather than fibrous or stringy. It must be in the annealed or softened state to be readily cut with files, saws, or drills.

Soft-center steel Soft-center steel is used in moldboards of plows and in cultivator shovels where it is desired to have a very hard wearing surface combined with high strength and toughness. It consists of a layer of mild steel welded between two layers of high-carbon steel. The outside layers can therefore be hardened while the center remains comparatively soft and tough.

Alloy steels Small amounts of one or more other metals, such as nickel, chromium, silicon, and vanadium, are commonly mixed with steel to form alloy steels. These metals are used in steel to give it certain desirable properties, such as great strength, resistance to corrosion, toughness, and resistance to shock.

Making grinding-wheel tests A good way to distinguish between many kinds of steel and iron is to grind them on a grinding wheel and

note the kind of sparks given off (see Fig. 12-1). Cast iron gives off a small volume of numerous small sparks. They are dull red as they leave the wheel but then change to yellow. Sparks from wrought iron are larger in total volume, are light yellow or red, and follow straight lines. Sparks from mild steel are similar but are more explosive or

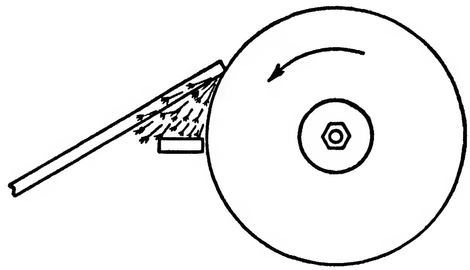


Fig. 12-1. Different grades of iron and steel may be distinguished by the sparks produced when ground on a grinding wheel. The higher the carbon content of the steel, the brighter and more explosive are the sparks.

forked. Tool steel gives off a moderately large stream of sparks that are lighter in color and still more explosive. The higher the percentage of carbon in steel, the brighter and the more explosive are the sparks.

2. LAYING OUT AND MARKING METAL

Careful measuring and marking of the work before cutting and shaping usually save time and ensure a better job. Measuring and marking on metal are done in much the same manner as on wood, except that a marking awl or scriber is recommended for marking metal (see Fig. 12-2). An old saw file ground to a needle point makes

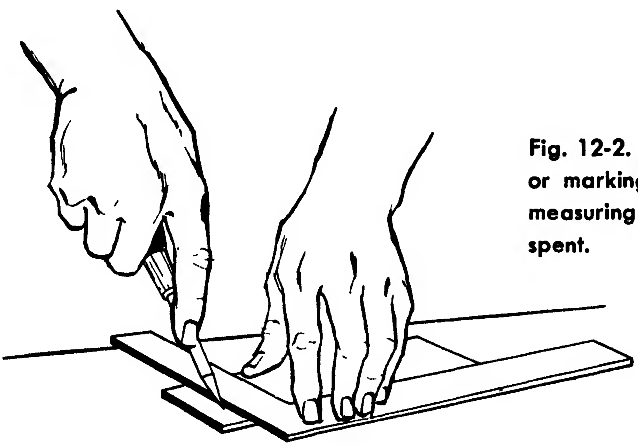


Fig. 12-2. Marking metal with a scriber or marking awl. Time spent in careful measuring and marking is time well spent.

a very good scriber. A center punch, or a prick punch which is ground to a sharper point than a center punch, is also valuable for marking locations for bends, drill holes, saw cuts, etc.

3. CUTTING WITH A COLD CHISEL

The cold chisel is an inexpensive tool that has a wide variety of uses in cutting cold metal. And like most other tools, its usefulness is greatly increased when it is kept well sharpened and used properly. (See Chap. 7, "Sharpening and Fitting Tools," page 230 for methods of grinding the cold chisel.) Good cold chisels may be bought, or if a blacksmith's forge is included in the shop equipment, they may be made and tempered in the shop.

Choose a chisel of a size suitable for the work being done. Use heavy chisels for heavy cutting and smaller chisels for light cutting. If the chisel is too small for the work, there is not only danger of breaking it, but it may vibrate and sting the hands when struck, and of course it will not cut so fast as a larger one.

Holding the chisel; striking Hold the chisel firmly enough to guide it, yet loosely enough to ease the shock of hammer blows and keep the hands from becoming tired. Always hold the hammer handle near the end and strike blows in accordance with the kind of cutting being done —heavy blows for heavy cutting and light ones for light work. Strike light blows mostly with motion from the wrist; medium blows with motion from both wrist and elbow; and heavy blows with motion not only from the wrist and elbow, but also from the shoulder.

Cutting on the anvil When cutting with the chisel at the anvil, be sure to cut on the chipping block, the small depressed surface at the base of the horn (see Fig. 12-3). The chipping block is soft, while the face of the anvil is hardened. Cutting through a piece on the face of the anvil would not only dull the chisel, but it would damage the face, which should be kept smooth for good blacksmithing.

Nick deeply, then break Bars and rods can generally be cut most easily by nicking them deeply on two or more sides and then breaking them by bending back and forth. Rods may be held in a vise for bend-

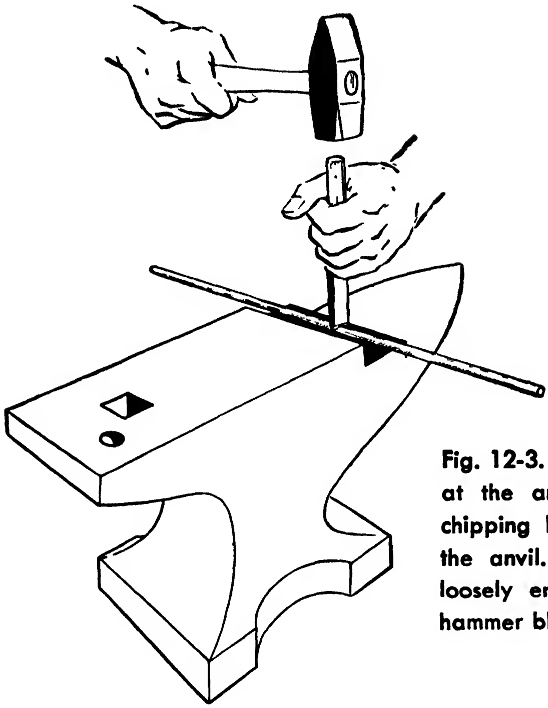


Fig. 12-3. In cutting with the cold chisel at the anvil, always work over the chipping block—not over the face of the anvil. Hold the chisel firmly, yet loosely enough to ease the shock of hammer blows.

ing, or if small enough they may be inserted in one of the punch holes in the anvil.

Cutting in the vise If a heavy vise is available, small and medium-size rods or bars may be clamped in the vise and nicked deeply by

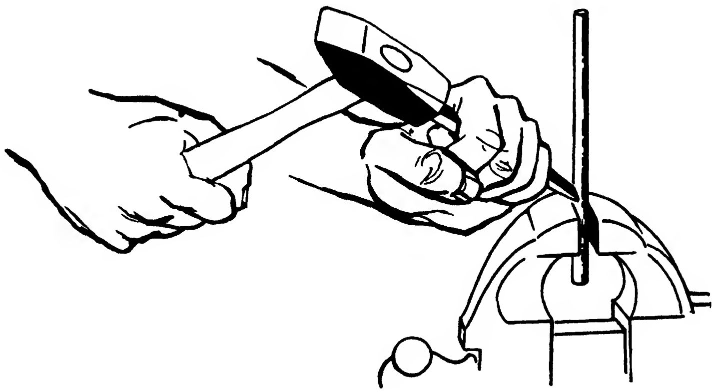


Fig. 12-4. Bars and rods may be cut roughly to length by nicking deeply on two or more sides with the cold chisel and then bending back and forth. When cutting in the vise, always cut as close to the vise jaws as possible and always strike so that the force of the blow is against the stationary jaw—not the movable one.

chiseling close to the jaws. The rods are then easily broken by bending. Always hammer so that the force of the blows will come against the stationary jaw of the vise and not against the movable one (see Fig. 12-4).

Shearing thin bars Thin bars and band iron up to about $\frac{3}{16}$ in. thick can usually be more easily cut by clamping in a vise and shearing with a cold chisel than by sawing. Clamp the bar or band iron securely in the vise with the cutting line just even with the top of the jaws. Place the chisel at one edge of the piece, with one bevel of the

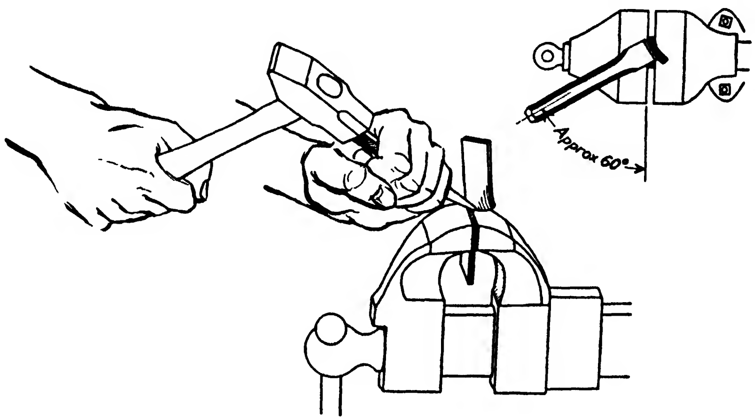


Fig. 12-5. Thin bars are easily sheared with a cold chisel and vise. Keep the lower bevel of the chisel flat against the vise and the chisel handle at an angle of about 60 deg with the line of cutting.

cutting end flat against the top of the vise jaws, and with the handle at an angle of about 60 deg to the line of cutting (see Fig. 12-5). The chisel then acts as one blade of a pair of shears, and the stationary vise jaw as the other blade.

When the chisel is properly placed, tap it lightly once or twice to get the proper direction for striking, and then strike firm, well-directed blows. It is important to keep the chisel placed so that it cuts close to the vise jaws, and yet does not cut into them and thus damage the vise and dull the chisel. Driving too straight against either the flat surface or the edge will not give a good shearing cut; also, driving too straight against the edge will cause the work to slip in the vise.

When the shearing is properly done, the metal cuts fast and easily, leaving a surface that is smooth enough for most work. Where smoother work is required, the surface is readily dressed with a file.

Sheet metal that is too thick for easy cutting with snips can be easily cut with a cold chisel and vise in the same manner as thin bars.

Cutting soft metals or thin sheet metal Soft metals like brass, lead, babbitt, or thin sheet metal are easily cut with the cold chisel. If much cutting of this type is to be done, it is best to use a chisel that has been ground to a very keen cutting edge of possibly 30 to 45 deg, instead of the usual angle of about 70 deg. The chisel will then cut both faster and smoother.

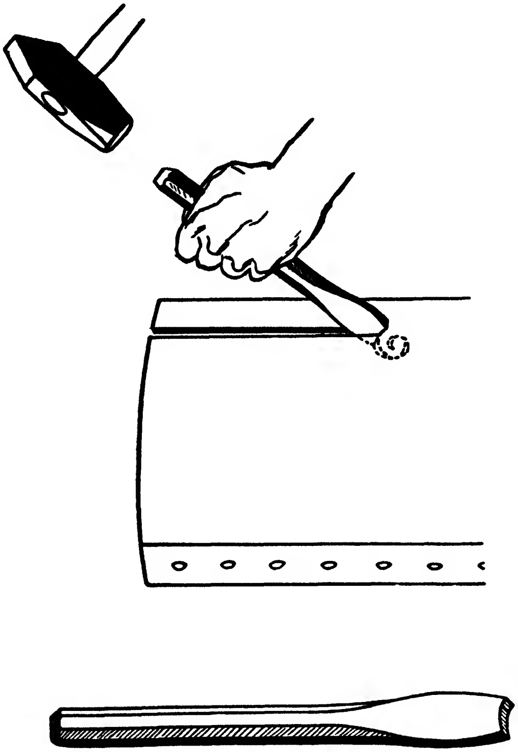


Fig. 12-6. Heavy sheet metal, oil drums, water tanks, etc., are easily cut with a slitting chisel.

Using a slitting chisel A special kind of cold chisel, known as a slitting chisel, is very useful for fast cutting of thick sheet iron, such as cutting out the head of an old oil drum or cutting it in two in the middle (see Fig. 12-6). The slitting chisel is ground to a blunt square end, instead of being ground with a beveled cutting edge like a regular cold chisel. The slitting chisel is slightly thicker at the cutting end than a little further back. It shears out a ribbon of steel just as wide as the cutting end.

To start a slitting chisel in the middle of a piece of sheet iron, first drill a hole. A little experimenting will quickly indicate the best angle of cutting. An angle of about 45 deg to the surface of the metal being cut is usually about right.

Cutting slots and grooves Other special chisels, such as those illustrated in Fig. 12-7, will occasionally be found useful in cutting grooves and slots, such as oil grooves in a bearing or a keyway in a shaft. If a forge is a part of the shop equipment, such chisels are easily made in the shop.

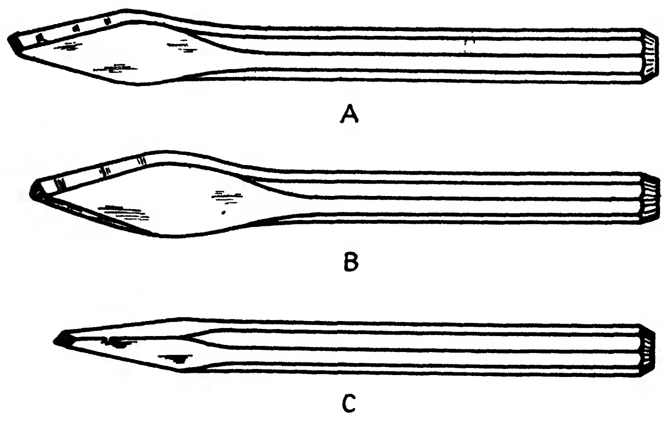


Fig. 12-7. Types of special grooving chisels that may be made in the farm shop: A, cape chisel for cutting keyways; B, round-nosed chisel for cutting round grooves; C, diamond-point chisel for cutting grooves.

Points on cutting with the cold chisel

1. Always use a sharp chisel and one of a size suited to the cutting to be done.
2. Hold the chisel firmly enough to guide it, yet loosely enough to ease the shock of the hammer blows.
3. Grasp the hammer handle near the end.
4. Tap the chisel once or twice to get the direction of striking, and then use firm, well-directed blows.
5. For light chiseling, strike blows with wrist motion only; for heavier work, use both wrist and elbow action; and for very heavy work, use motion from the shoulder as well as wrist and elbow.
6. In cutting at the anvil, always work over the chipping block and not the face of the anvil.
7. Nicking a bar deeply and then breaking it by bending is usually easier than cutting it all the way through with a chisel.
8. In hammering in a vise, always strike so that the force of the blow comes against the stationary jaw and not against the movable jaw.
9. For shearing in a vise, clamp the work tight and place the chisel so as to get a good shearing cut. Keep the bevel on the end of the chisel flat against the top of the vise jaws. Hold the chisel at an angle of about 60 deg to the line of cutting.
10. For cutting brass and similar soft materials or thin sheet metals,

the chisel cuts smoother and faster if ground to an angle of 30 to 45 deg instead of the usual angle of about 70 deg.

11. A slitting chisel is very useful for fast cutting of thick sheet iron, such as cutting an old oil drum in two.

4. FILING

A file is a most valuable cutting tool. Its real value is rarely fully appreciated by the beginner. Unless a file is properly cared for and used, however, it will do only moderately satisfactory work, and filing with it will prove tedious and laborious. On the other hand, when a file is properly cared for and used, a good workman can often do faster and better cutting with it than he can with a grinding wheel.

Taking care of files A file is a hardened-steel tool that has a series of small sharp cutting edges, or points, on its surface. Files should there-

Fig. 12-8. A good way to keep files. Do not keep them in a drawer or on a shelf where the sharp cutting edges might be dulled by contact with other files or tools.

fore not be thrown around with wrenches and other tools, nor should they be kept on shelves or in drawers where they will scrape against each other or against other tools. A good method of keeping them when not in use is to hang them on hooks or on a rack by the handles, as shown in Fig. 12-8.

Keep file handles tight on the tangs. If a handle becomes loose, it

can usually be tightened by ramming the file lightly, handle end down, against the bench top.

It is also important that files be kept clean, that is, free from filings or chips, rust, grease, and grime.

Selecting the right file for the job There are hundreds of styles, kinds, and sizes of files, and for best results the file should be selected to fit the job at hand. Fortunately, a rather small assortment of files will meet ordinary requirements in farm shopwork.

Files may be classified according to (1) size; (2) kind of teeth; (3) shape, style, or use; and (4) degree of coarseness or fineness.

Size of files The size of a file is designated by its length, measured exclusive of the tang.

Kinds of teeth A file with one series of chisellike teeth running at an angle across the face is known as a *single-cut file*. A *double-cut file* has a second series crossing the first at an angle. A third kind, used on rasps, consists of raised points on the surface, rather than chisellike teeth.

Shape, style, or use Files are commonly named to indicate (1) their general style or shape, as *flat, square, round, half-round, three-cornered* (*triangular*); or (2) their particular use, as *mill* and *auger bit*.

A particular kind of file is always made in just one kind of teeth. A *flat* file, for example, cannot be obtained with either single-cut or double-cut teeth. It is made in double-cut only. Likewise, a *mill* file is made in single-cut only. A mill file, so called because of its use in woodworking mills for sharpening saws and planer knives, is very much like a flat file except that it is somewhat thinner, is tapered less in width near the point, and is made with single-cut teeth.

Fineness or coarseness of cut The fineness or coarseness of files is commonly designated by the following series of terms, which are arranged in the order of coarsest first: *rough, coarse, bastard, second cut, smooth,* and *dead smooth*. These terms are relative, however, and vary with the kind or style of file and with the length or size of file. For example, a mill bastard file is finer than a flat bastard file of the same size; and an 8-in. bastard file is finer than a 10-in. bastard file.

For rough, fast cutting, use a flat bastard (double-cut) file, 10, 12, or 14 in long. For finer work, a mill bastard (single-cut) file 8 or 10 in. long is usually satisfactory. For still finer work, a mill smooth file would be better.

For miscellaneous filing jobs and for filing small pieces or working in close quarters, a small assortment of half-round, round (rattail), triangular, and square files is an asset to any shop.

Holding the file For heavy filing, grasp the file handle firmly in the right hand, *thumb on top.* Do not squeeze too tightly. Hold the end of the file between the ends of the first two fingers and the base of the

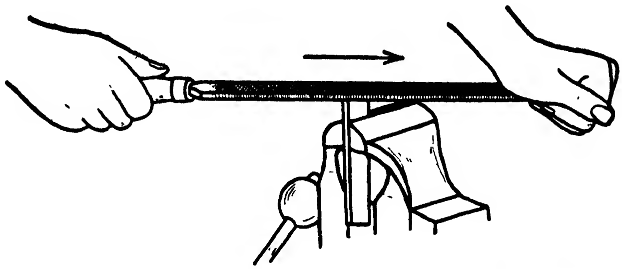


Fig. 12-9. A good way to hold a file for heavy filing. Hold the handle firmly, yet not too tightly, with the right hand. Keep the thumb on top. Apply moderate to heavy pressure with the left hand.

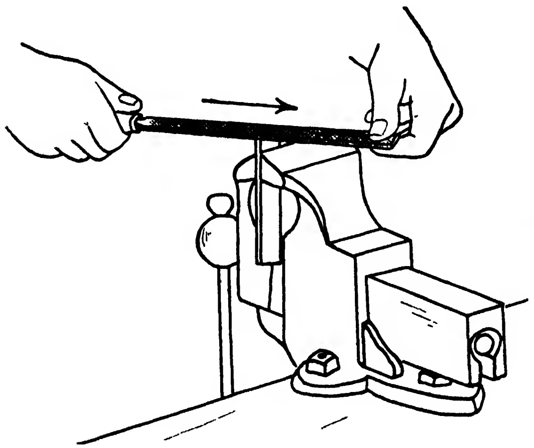


Fig. 12-10. A good way to hold the file for light filing. Hold the end of the file between the thumb and finger of the left hand.

thumb of the left hand (see Fig. 12-9). Apply moderate to heavy pressure.

For light filing, hold the end of the file between the *end of the thumb* and the fingers of the left hand. Use light to moderate pressure (see Fig. 12-10).

Wherever possible, clamp the work to be filed securely in a vise.

Elbow height, or possibly a little lower, is best for rough, heavy filing. A little higher is better for light filing.

Using the file Probably the most important points to observe in filing are (1) *to use rather slow, full-length cutting strokes, and* (2) *to lift the file or release the pressure on the backstrokes.*

In heavy filing, push the file with a combination slow rhythmic swing from both the body and the arms. Stand in front of the vise, with the right foot about 10 to 12 in. in back of the left and with the body bending forward slightly at the hips (see Fig. 12-11).

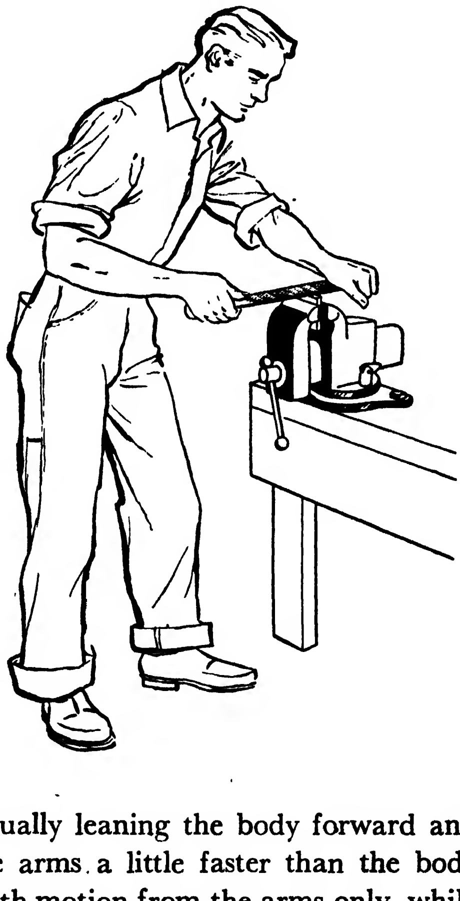


Fig. 12-11. In filing, stand with the left foot 10 or 12 in. ahead of the right, and with the body leaning forward slightly at the hips. Use rather slow, full-length strokes, and lift the file slightly or release the pressure on the backstrokes.

Start the forward stroke by gradually leaning the body forward and at the same time pushing with the arms a little faster than the body moves. Finish the forward stroke with motion from the arms only, while the body swings back into position for the next cutting stroke. Then lift the file slightly or release the pressure, and quickly draw it back into position for the next cutting stroke.

Use the right amount of pressure One of the quickest ways to ruin

a file is to use too much or too little pressure on the forward or cutting stroke. Different materials require different pressures. In general, use just enough pressure to keep the file cutting. If too little pressure is used and the file is allowed to slide over the work without cutting, the teeth will rapidly become dull, particularly in filing hard metals. If too much pressure is used, the file will "overload" with cuttings. This is likely to chip or clog the teeth and also scratch and score the work.

On the backstroke, there should be very little or no pressure. It is usually best to lift the file clear off the work.

Never use short, jerky, or seesaw strokes Only a poor workman or an amateur would use short, jerky, or seesaw strokes. When used in such a manner, the file cuts slowly, does poor work, and soon becomes dull.

When a file is pushed too fast, it slides over the metal without properly engaging it, which causes slow cutting and quick dulling of the teeth. Also, the work is likely to vibrate, causing screeching. *Always push a file slowly enough for the teeth to "take hold" and cut.*

Filing a surface flat and straight When filing a narrow, flat surface, use more pressure on the front end of the file than on the handle during the first part of the stroke. Then as the file is pushed forward, gradually ease the pressure on the front end and place more on the handle. In this way, the file may be kept cutting straight and flat all the way across. Unless the pressure on the file is shifted in this manner, the edges of the work will be filed more than the middle portion, and the surface will be rounded instead of flat and straight.

Drawfiling Drawfiling is a quick, easy method of filing long, narrow surfaces or round rods. To drawfile, grasp the file on the ends as shown in Fig. 12-12 and push it sidewise. Hold the handle end in the right hand. Use pressure on the forward stroke, and lift the file slightly or release the pressure on the backstroke if a single-cut file is used. If a double-cut file is used, pressure may be exerted on both the forward and back strokes, since one set of teeth would cut on one stroke and the other set on the other stroke.

In blacksmithing, drawfiling can often be used to smooth up a round rod or other piece of work better than hammering. If the work is to be filed while hot, use an old file that can be kept for this purpose, as the heat would soon damage a good one.

Cleaning the file Small particles of metal will often tear out and lodge between the file teeth and scratch the work. This is more likely to occur with a new file than with an old one, or when filing on narrow work, especially if too much pressure is used. Rubbing the file with a piece of chalk will help prevent clogging and scratching. A file is also

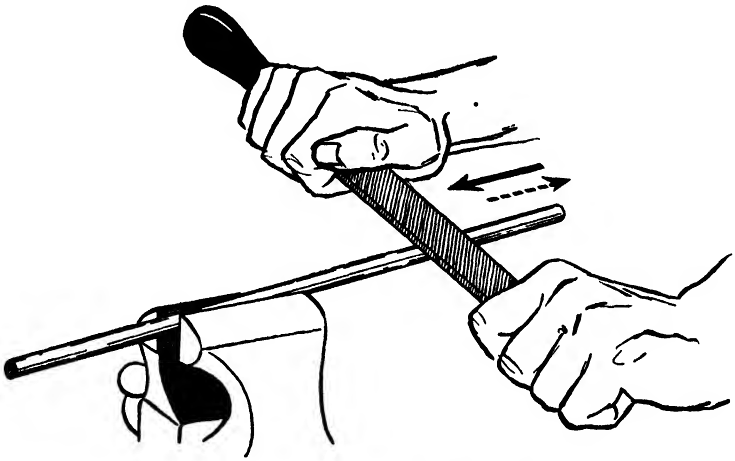
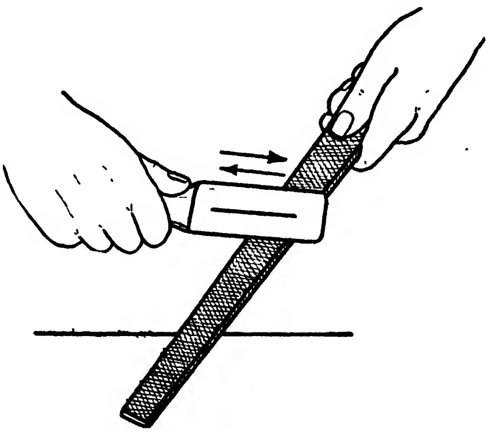


Fig. 12-12. Drawfiling is an excellent method for filing long, narrow surfaces. Push the file back and forth sideways, applying pressure on the forward strokes and releasing it on the backstrokes if a single cut file is used. Use moderately slow strokes.

Fig. 12-13. When a file becomes clogged with dirt, grease, or metal cuttings, it may be cleaned with a small wire brush known as a file card.



likely to become clogged and slick when filing soft metals or dirty, greasy pieces.

After every few strokes, tap the end of the file, on the bench to shake the filings from the teeth. Also, clean the teeth frequently by using a file brush or a file card (a small fine wire brush) as shown in Fig. 12-13. A piece of soft iron wire sharpened to a point and known

as a *scorer* may also be used to remove cuttings that become lodged between file teeth. Most file cards and brushes have scorers attached. Another way to clean lodged cuttings from file teeth is to drag the edge of a thin piece of soft brass or copper along lengthwise of the teeth.

Filing soft metal It is difficult to file soft metal with an ordinary file, because of the tendency of the teeth to clog. Drawfiling, however, usually works reasonably well and better than straight filing. Special files for brass, aluminum, and lead work much better than ordinary files.

Filing cast iron Cast iron has a hard outer surface that would quickly damage the teeth of a good file. In filing cast iron, it is therefore good practice to use an old file for cutting through this outer surface before using a good file.

Points on filing

1. Clamp the work to be filed firmly in the vise to prevent chattering.
2. The work should be at about elbow height for average filing, possibly a little lower for heavy filing, and a little higher for light filing.
3. Exert just enough pressure on the file to keep the teeth cutting.
4. Use moderately slow, long, full-length strokes.
5. Always lift the file or release the pressure on the backstroke.
6. Never use short, jerky strokes.
7. Do not allow the file to slip over the work, as this dulls the teeth.
8. Do not allow files to be thrown around against tools or against each other, as this will damage the teeth.
9. A good way to keep files is to hang them up by their handles.
10. If a file tears and scratches the surface of the work, rub the teeth with chalk.
11. Keep the teeth of the file clean by means of a file card or brush.
12. Drawfiling works well on long, narrow surfaces.
13. Drawfiling on soft metals gives rapid cutting with a minimum of clogging of the teeth.
14. In filing cast iron, first remove the hard outer surface with an old file before using a good one.

15. An 8- or 10-in. mill bastard file is good for fine filing, and a 12-in. flat bastard file is good for fast, rough filing.

5. HACK SAWING

The hand hack saw is one of the most useful tools for cutting metal. Like the file, however, it is often not used properly. Although the hack saw can be used with fair satisfaction by an inexperienced workman, a little thought and study given to its proper use will result in faster and better work and less dulling and breaking of blades.

Selecting the right saw blade for the job Good work with a hack saw depends not only upon the proper use of the saw, but also upon proper selection of the blades for the work to be done. There are three general kinds of blades available: (1) all-hard, (2) flexible, and (3) high-speed steel. All-hard blades have the whole blade tempered. They are suitable for general use where the work to be sawed can be held securely. The flexible blades have only the teeth hardened, not the back. They are used where there is danger of cramping and breaking the blade, as in sawing in awkward positions, where the work cannot be held securely, or for sawing flexible material like armored electric cable. High-speed steel blades are made of a special steel and will cut faster and last many times longer than regular blades, provided they are carefully used and not broken.

Use of saw blades with the wrong size of teeth is a common cause of breaking blades and of stripping teeth from the blade. *In general, use larger teeth for sawing thick pieces and soft materials and smaller teeth for thin pieces and hard materials.* Fine teeth lessen the danger of stripping teeth from the blade and of breaking the blade.

Hand hack-saw blades are commonly available with 14, 18, 24, and 32 teeth per inch. A blade with 14 teeth per inch is best for sawing thick bars and soft materials, although a blade with 18 teeth per inch is usually satisfactory for the heavier sawing. For general use, a blade with 18 teeth per inch is usually best for the experienced workman, while a blade having 24 teeth per inch is best for beginners. A blade with 32 teeth per inch is best for sawing thin metal and tubes with walls thinner than about $\frac{1}{16}$ in. A general rule is to use a blade that will always have at least two teeth cutting at the same time. This

lessens the tendency of teeth to catch on the work and break out of the blade.

Inserting and tightening the blade in the frame Insert the blade in the frame with the teeth pointing away from the handle, and tighten it until it gives a humming note when picked with the thumb (see Fig.

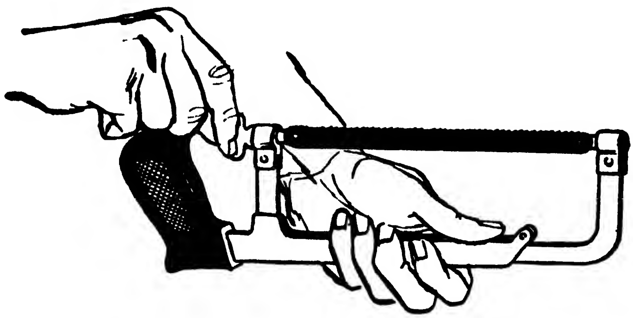


Fig. 12-14. Tighten a hack-saw blade until it gives a humming note when picked with the thumb. After a few strokes, a new blade will stretch and need to be retightened a little.

12-14). After a little sawing, it may be necessary to retighten the blade. It is important to keep the blade tight but not overstrained. A slack blade is likely to drift or cut at an angle instead of straight, and it is likely to buckle and break.

Holding and using the saw Hold the handle of a hack saw in much the same manner as you hold a hand wood saw. Hold the front of the frame with the left hand to help guide it and apply pressure (see Fig. 12-15). Stand at ease with the right foot 10 or 12 in. back of the left

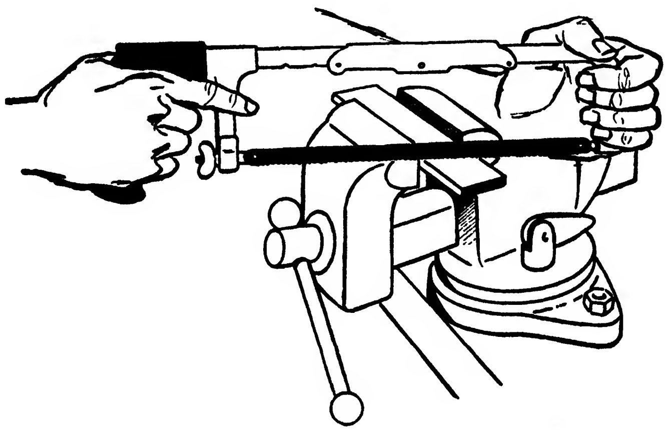


Fig. 12-15. Grip the saw with the first finger of the right hand alongside the handle. Hold the front end of the frame with the left hand to help guide the saw and apply pressure.

and with the right forearm, elbow, and shoulder in line with the saw (see Fig. 12-16). Push the saw with a slight sway of the body as well as with motion from the arms, much as a file is pushed (see page 369).

Use long, slow, even strokes Do not work too fast. Sixty cutting strokes per minute should be the maximum—40 to 50 are usually better.

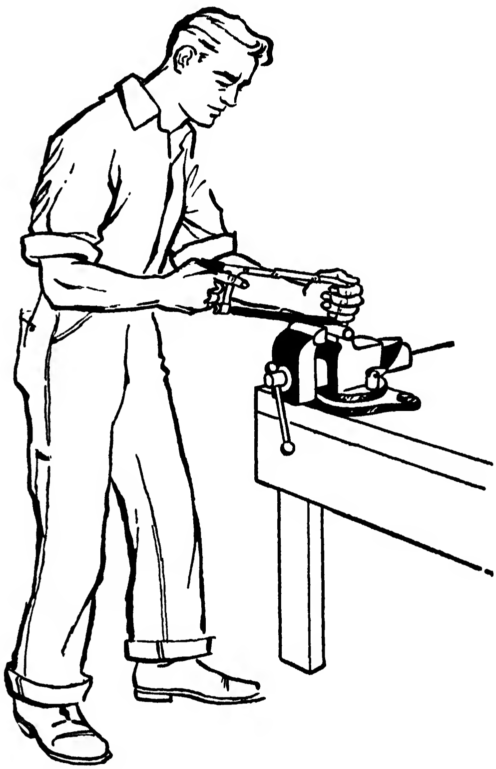


Fig. 12-16. In sawing with a hack saw, stand at ease with the right foot 10 or 12 in. back of the left, and with the right forearm, elbow, and shoulder in line with the saw. Use long, even strokes, swaying the body back and forth slightly in rhythm with the arm strokes.

Exert pressure on the forward strokes, and release the pressure, or lift the blade slightly, on the backstrokes. Use just enough pressure to make the teeth cut and keep them from slipping over the work. If they slip, little or no cutting is done, and the blade is quickly dulled. Too much pressure increases the danger of breaking the blade.

Sawing too fast is usually accompanied by short strokes and heavy dragging on the backstrokes, with consequent quick dulling and excessive wear in the middle portion of the blade. Also, with fast sawing there is more danger of catching and breaking the blade.

If a blade starts to cut to one side, it is best to turn the stock a quarter or half turn and start a new cut.

In case a blade is broken and a new one must be used, always start in a new place, possibly on the opposite side of the stock. A new blade would bind, and there would be danger of breaking it if it were used in a cut started by an old blade.

Holding the work A piece to be sawed should be held securely. If possible, clamp it in a vise with *the sawing line close to the vise jaws.*

Beginners often make the mistake of sawing too far from the vise, thus allowing the work to spring and vibrate, which results in poor work and increases the danger of catching and breaking the saw blade. Sawing can best be done with the work at about elbow height.

In fastening irregular-shaped pieces, as angle irons or channel irons, in a vise, clamp them so that the saw will make an angling cut and enough teeth will engage at a time to prevent catching and breaking

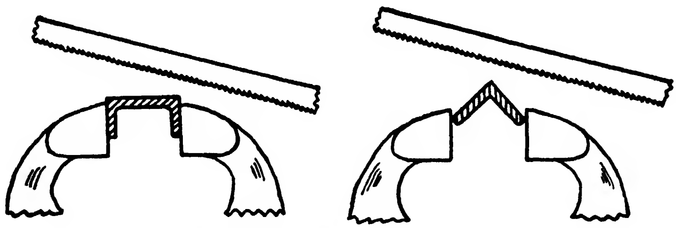


Fig. 12-17. Suggested methods of holding irregular work for hack sawing. In cutting channels and angle irons, keep several teeth in contact with the work.

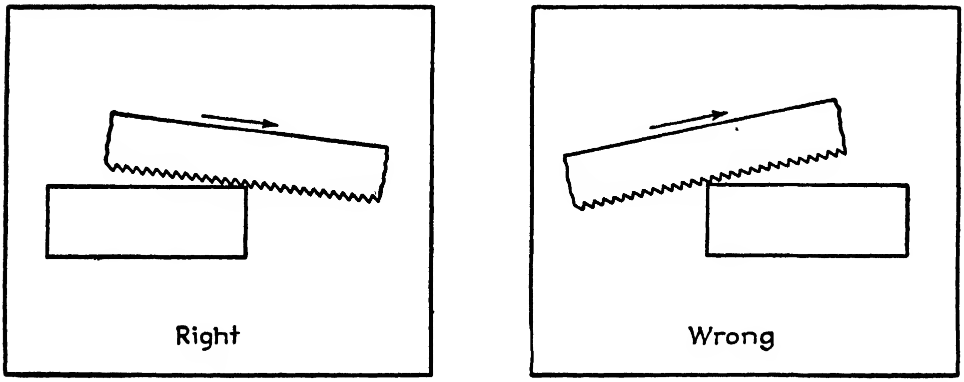


Fig. 12-18. In sawing thin bars, clamp them flatwise in the vise (not on edge), and saw with the front end of the saw slightly lowered. (See also Fig. 12-15.)

(see Fig. 12-17). At least two teeth, preferably more, should be in contact with the work. In sawing thin bars, ⅛ to ¼ in. thick, clamp them flatwise in the vise, rather than on edge, and saw with the front end of the saw slightly lowered (see Fig. 12-18). Sawing across the wide surface instead of the edge not only lessens the danger of stripping teeth from the blade, but also prevents vibration.

To hold a piece of metal in a vise without marring it, clamp it between two pieces of wood.

Starting the saw in a file notch It is a good plan to file a notch for starting the saw, as shown in Fig. 12-19, particularly in the case of beginners or when starting on the corner of a bar. The notch helps get the saw started in the right place and decreases the danger of breaking teeth from the blade.

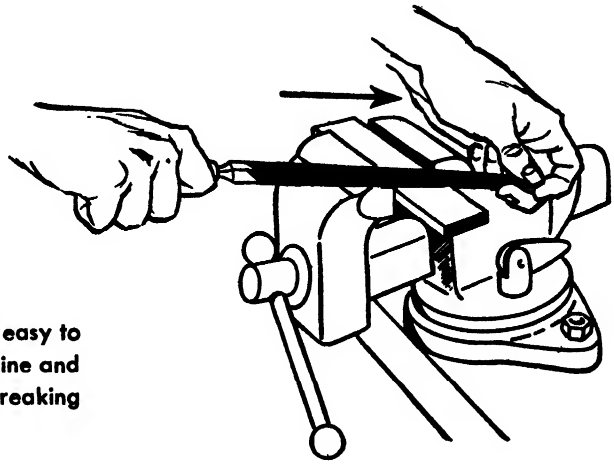


Fig. 12-19. A file notch makes it easy to start the hack saw exactly on a line and decreases the danger of breaking teeth from the blade.

Sawing tool steel Be sure tool steel is in the softened or annealed state before sawing. Otherwise, the saw blade will be quickly dulled. Tool steel is ordinarily in the annealed state when bought. Although tool steel may be sawed like ordinary steel, a good way is to saw only a deep

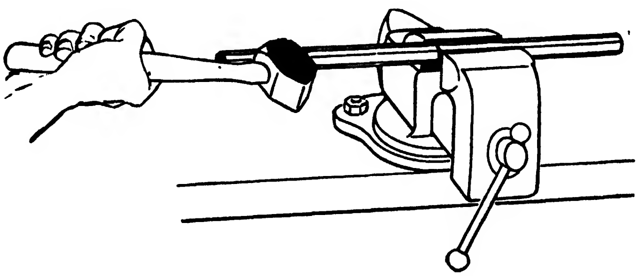


Fig. 12-20. A practical method of cutting tool steel is to saw a deep nick with the hack saw, clamp it securely in a vise with the nick even with the movable vise jaw, and then break it with a sharp hammer blow.

nick (about one-fourth or one-fifth the way through the bar) and then to break the bar by clamping in the vise and striking a sharp blow with the hammer (see Fig. 12-20). Clamp the bar with the saw nick on the side to be struck with the hammer, and just even with the movable vise

jaw. In heavy hammering in a vise, always strike so that the force of the hammer blows will come against the stationary jaw.

Sawing thin metal A small piece of thin sheet metal may be easily sawed by clamping it between two pieces of wood in a vise and sawing through both wood and metal (see Fig. 12-21). Larger pieces of sheet

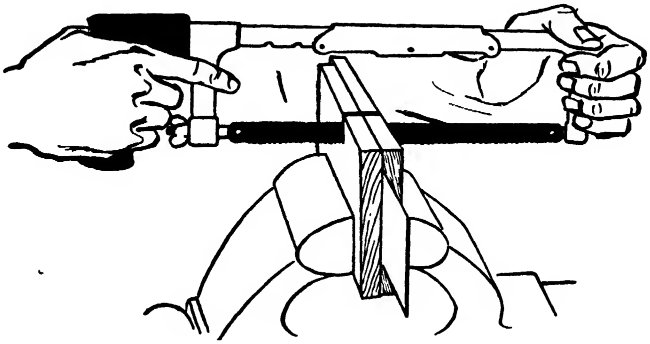


Fig. 12-21. A small piece of thin metal may be sawed easily by clamping it between pieces of wood in a vise and sawing through both wood and metal.

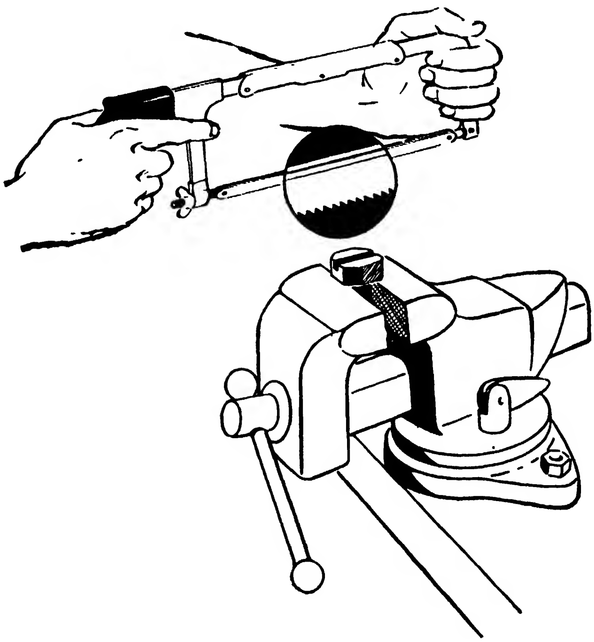


Fig. 12-22. Wide slots are easily made with the hack saw by using two or more blades instead of one.

metal that cannot be held in a vise may be clamped to the bench top with the part to be sawed projecting over the edge.

Sawing wide slots It is sometimes desirable to make a wide slot in a bolthead so that it may be held or turned with a screw driver or a thin bar. Such a slot is easily made by using two saw blades in the hack saw instead of one (see Fig. 12-22). If for some reason a still wider slot is needed, three blades might be used.

Points on hand hack sawing

1. Clamp the work in a vise if possible.
2. Saw as close to the vise jaws as possible in order to keep the work from vibrating.
3. Use a flexible blade for sawing flexible material, or where the work cannot be securely held.
4. It is a good plan to start the saw in a notch made with a file.
5. Use a blade with a suitable number of teeth per inch. Twenty-four is about right for general use, especially for beginners. Eighteen teeth per inch might be better for an experienced workman.
6. Use a blade with 32 teeth per inch for sawing thin metal.
7. At least two teeth should be kept in contact with the work when sawing.
8. Coarser teeth saw faster; finer teeth lessen the danger of breakage.
9. Keep the blade tight, yet not overstrained. If it is properly stretched, it will give a humming note when picked with the thumb.
10. Use just enough pressure to make the teeth cut.
11. Release the pressure on the backstroke.
12. Use long, even, slow strokes—not over 60 cutting strokes per minute; 40 to 50 are usually better.
13. Never allow the saw to rub or slip instead of cutting. Rubbing and slipping dull the teeth.
14. To saw irregular-shaped pieces, clamp them cornerwise in the vise, so as to allow plenty of teeth in contact with the work.
15. Clamp thin bars flatwise rather than on edge. This prevents vibration and lessens the danger of stripping teeth.
16. Tool steel is readily cut by sawing a deep nick and then clamping in the vise and breaking with a hammer.

17. Thin metal may be sawed by clamping it between pieces of wood and then sawing through both wood and metal.
18. Two or more blades may be used in a hack saw for sawing wide slots.

Using power hack saws A power hack saw is a great time and labor saver in a shop where much metalwork is done. It will cut much faster and more accurately than can usually be done by hand. In cutting heavy bars, the saw may be started and allowed to run by itself while other work is being done in the shop.

A saw which will make a square cut in stock up to 4 by 4 in., and which takes a standard 12-in. power hack-saw blade, is a good size

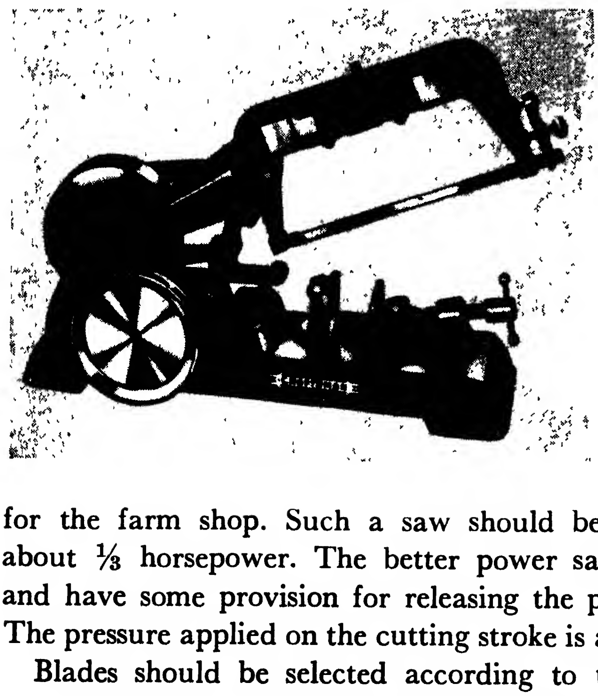


Fig. 12-23. The power hack saw is a great time and labor saver and will do better work than can be done by hand. (Sears, Roebuck and Co.)

for the farm shop. Such a saw should be operated by a motor of about ⅓ horsepower. The better power saws cut on the pull stroke and have some provision for releasing the pressure on the backstroke. The pressure applied on the cutting stroke is adjustable.

Blades should be selected according to the kind of sawing to be done. Blades with 18 teeth per inch are recommended for cutting thin sections like angle iron, pipe, and tubing, and are generally quite satisfactory for general work in the shop. Coarser-toothed blades with 14, or even 10, teeth per inch may be used for faster cutting in heavy stock. High-speed blades are usually preferred.

The general principles which apply to hand hack sawing apply also to power hack sawing. Some of the main points to be observed in operating a power hack saw are given below:

Points on power hack sawing

1. Always clamp the work securely in the saw vise.
2. Before starting the saw, be sure the blade is up out of contact with the work. After the blade is in motion, let it down gently onto the work, holding up on the handle slightly to reduce the pressure while the blade is starting its cut.
3. Use a suitable cutting pressure on the blade, just enough to keep it cutting well. Reduce the pressure when sawing thin work.
4. Always keep the blade tight in the saw frame.
5. Clamp the work so that the blade will not have to cut straight across thin sections.
6. Clamp angle irons with the ridge up. Two or more may be cut at the same time by nesting them.
7. Be sure to insert the blades so that the teeth will point in the direction of cutting.
8. Do not push down on the saw to add pressure to the blade. The teeth can cut only as fast as their size will permit.
9. Run the saw at the speed recommended by the manufacturer.

6. SELECTING DRILLING EQUIPMENT

Equipment for drilling holes in metal ranks high in importance and usefulness in the farm shop. A few drilling tools will enable a farmer to make many repairs on his machinery and equipment, and to make many handy appliances that would otherwise be impossible to make. There are many different types of drilling tools and machines from which to choose. Which ones to select will depend largely on the amount and kinds of drilling work to be done, the preferences of the buyer, and the amount of money to be invested. Different drilling tools and machines are discussed in the following paragraphs, somewhat in the order of their desirability for use in the farm shop.

The electric drill Probably the most useful of all pieces of drilling equipment for the farm shop is the electric drill. It is readily portable and is very convenient for drilling holes in a machine or implement without having to take it, or a part of it, into the shop.

By use of a suitable stand (see Fig. 12-25), the electric drill can be quickly converted into a stationary drill press for general drilling in

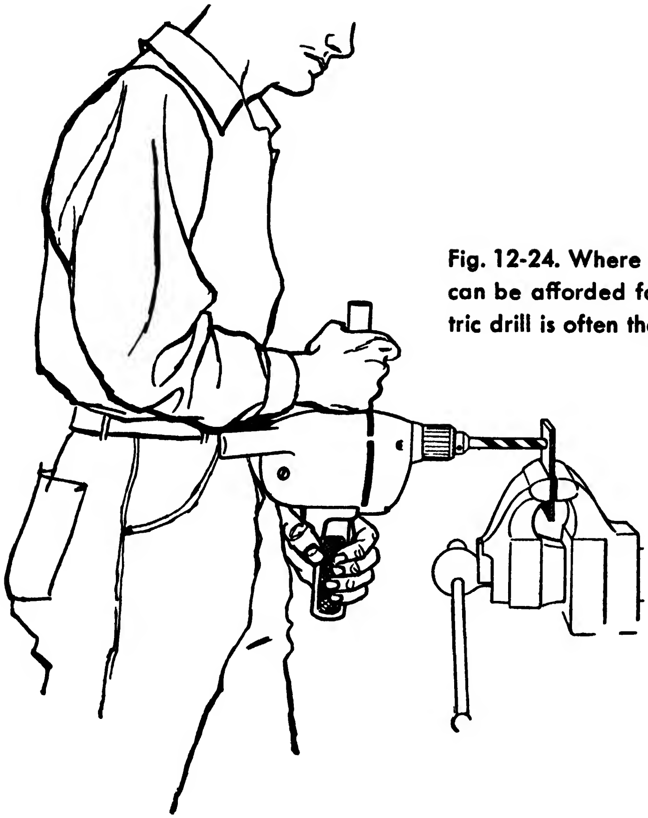


Fig. 12-24. Where only one drilling tool can be afforded for the shop, the electric drill is often the choice.

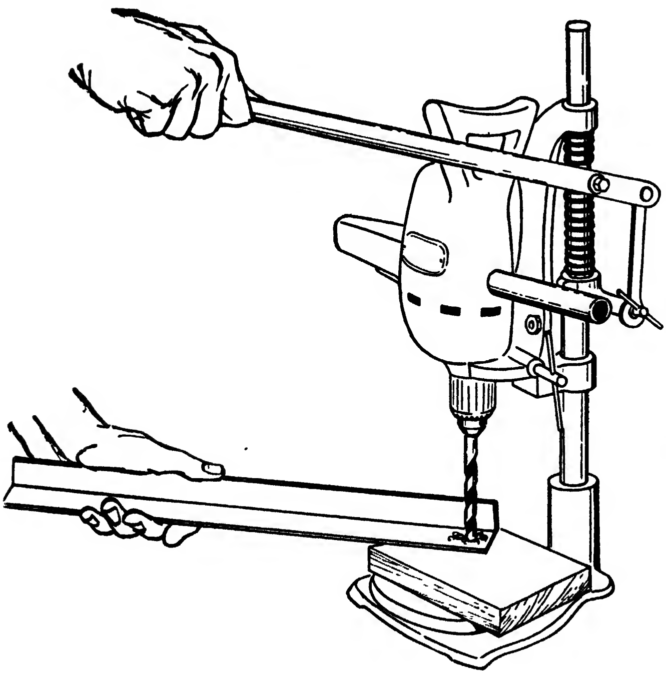


Fig. 12-25. The electric drill mounted in a drill stand can be used as a drill press.

the shop. The electric drill is also good for drilling holes in small pieces held in a vise. When the work is held in the vise at about waist level, the operator can easily lean against an electric drill to furnish drilling pressure.

Sizes of electric drills The size of an electric drill is designated by the maximum diameter of hole it is recommended to drill in steel. The sizes commonly used in farm shopwork range from ¼ in. to ⅝ in. Electric drills can drill or bore holes in wood about twice their rated size for steel. Electric drills of the smaller sizes are available in light-, medium-, and heavy-duty models. Medium-duty drills are usually quite satisfactory for farm shopwork. If only one electric drill can be afforded, a ½-in. drill should probably be chosen. Where two drills can be afforded, a ½- or ⅝-in. drill and a ¼-in. drill would make an excellent combination. The small drill is much lighter and more convenient for drilling small holes. If two sizes of electric drills cannot be justified, then a hand drill (Fig. 12-27) can be used quite satisfactorily for drilling very small holes.

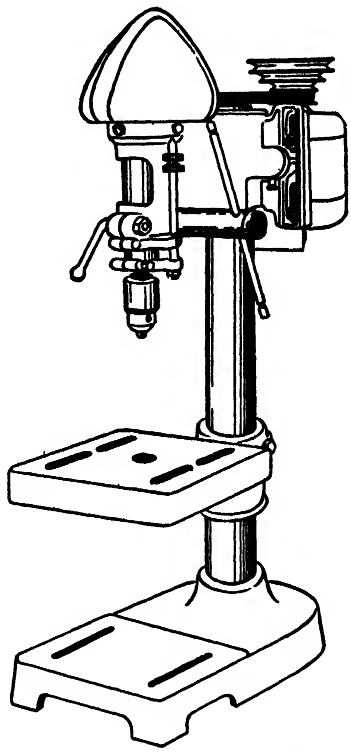


Fig. 12-26. The drill press is a preferred drilling machine for general use inside the shop.

The drill press For general drilling inside the shop the drill press is without doubt the most convenient and most satisfactory drilling machine. A bench drill press (Fig. 12-26) or a floor model which will drill to the center of a 14- or 15-in. circle, and which will drill holes up to ½ in., is quite satisfactory for most farm shops. A larger drill press would occasionally be useful, but considering its higher cost and the rather infrequent need for a larger drill, it is usually not recommended for the average farm shop.

Drill press speeds Drill presses are available with various ranges of drilling speeds. Some are available in high-speed and slow-speed models. The slow-speed models are better suited to the farm shop. The high-speed models are often used in home and hobby shops and are designed

primarily for drilling and working in wood. Table 12-1 gives the recommended drilling speeds for various sizes of drills and for different materials. In general, a drill press with a speed range from about 300 or 400 up to about 2,000 rpm will be satisfactory for most work in the farm shop.

TABLE 12-1. Drill Speeds in RPM for Carbon-steel Drills
(Speeds May Be Doubled for High-speed Drills)

Drill diam., in.	Mild steel	Cast iron	Tool steel	Soft metals
1/16	3667	4278	1833	9168
1/8	1833	2139	917	4584
3/16	1222	1426	611	3056
1/4	917	1070	458	2292
5/16	733	856	367	1833
3/8	611	713	306	1528
7/16	524	611	262	1310
1/2	458	535	229	1146
9/16	412	481	183	1031
5/8	367	428	153	917
3/4	306	357	131	764

The hand drill The hand drill (Fig. 12-27) is a very useful tool for drilling small holes in lightweight metal and in wood, and it should be included in the shop equipment, except possibly where a small electric drill is already on hand.

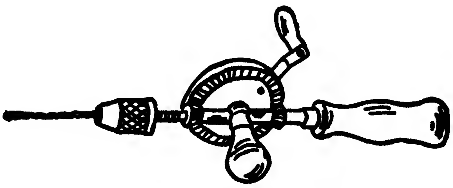


Fig. 12-27. The hand drill is one of the most useful tools for drilling small holes, either in metal or in wood.

The blacksmith's post drill The old-style blacksmith's post drill is a very useful drilling machine where electricity is not available. Most models are simply equipped with a crank for hand turning, although many may be purchased with pulleys so that they may be operated by a motor or an engine. Turning a post drill by hand is not hard

work, particularly if the drill bits are kept in good condition. The post drill is very good for drilling holes from about ¼ or 5/16 in. up to about ¾ in. Most post drills have adjustable self-feeding devices for automatically putting pressure on the drill bit as it is turned.

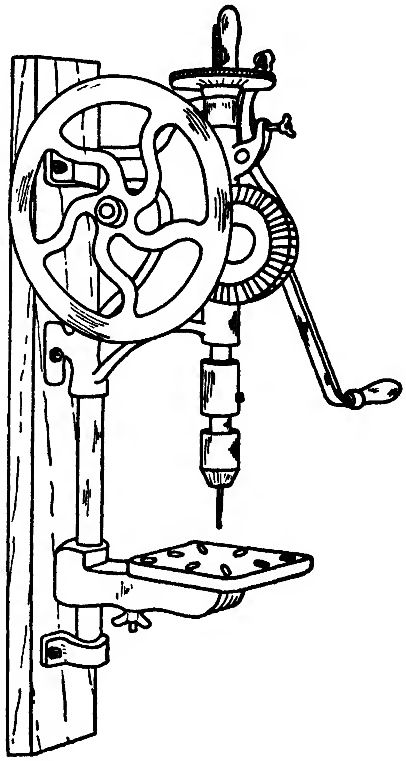


Fig. 12-28. The blacksmith's post drill is an excellent drilling machine for a shop where electricity is not available.

Drill bits for the farm shop There are two general classes of twist drills available, carbon steel and high-speed steel. High-speed drills are made of special alloy steel and can be operated at about twice the speed of carbon-steel drills without overheating and burning. They are considerably more expensive, particularly in the larger sizes.

It is a good practice to buy high-speed drills in the smaller sizes, say up to about ⅜ in., and carbon-steel drills in the larger sizes, for general shop use.

Types of drill shanks Twist drills are made in different styles of shanks (see Fig. 12-29), and drilling tools or machines are equipped with difficult kinds of chucks to hold drills. The most common type of shank for drills used in farm shops is the straight round shank, and the most common type of chuck is the 3-jaw, self-centering chuck. In equipping a shop with drills and drilling equipment, it is probably best to standardize on the straight round shank and the 3-jaw chuck.

Drills to be operated in the carpenter's bit brace are equipped with square tapered shanks, and are called bit-stock drills. Most blacksmith's post drills are equipped with chucks to hold drills with straight round shanks with one flat side. Many of these chucks have a flat side in the hole to register with the flat side of the drill. The turning force is then applied directly to the drill, and not through a setscrew in the chuck.

Drill presses used in factories and in commercial repair shops,-

particularly for operating twist drills larger than ½ in., commonly have spindles with tapered holes to receive drills with round tapered shanks. Such a drill has a flat tang on the end to fit into a matching hole in the drill-press spindle. The taper on the shank accurately centers the drill in the spindle, and the turning force is transmitted to the drill bit through the flat tang.

Other types of drill bits Besides regular twist drills, other types of drilling and boring bits are available for use in power drilling machines. Among the more important of these are wood augers, wood-drilling twist drills, flat-end wood-boring bits, and carbide-tipped masonry drills. The masonry drills are especially good for drilling holes in concrete with a large-size electric drill. Regular twist drills in sizes up to ½ in. but with shanks ¼ in. in diameter are available for use in small electric drills for drilling in wood or other easily drilled materials.

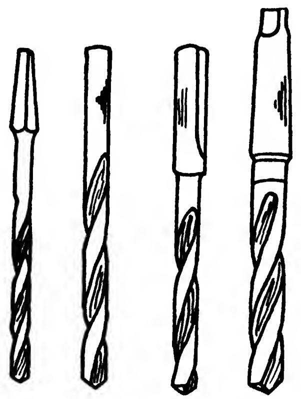


Fig. 12-29. Types of drill bits classified according to kind of shanks: A, bit-stock drill; B, straight round shank drill; C, blacksmith's drill (straight round shank with flat side); D, morse taper drill.

Sizes of twist drills needed A set of 15 drills ranging in size by thirty-seconds from ⅟₁₆ to ½ in. would be practically ideal for farm shopwork. A few in-between sizes under ½ in. might be added occasionally as special need for them arises, and also a few sizes above ½ in. if an electric drill or other suitable drilling machine is available for drilling larger-size holes. Where some saving in first cost is necessary, a set of drills ranging in size from ⅟₁₆ to ¼ in. by thirty-seconds, and from ¼ to ½ in by sixteenths is recommended.

Small drills are available in sizes designated by letters from A to Z, and by wire-gage numbers from 1 to 80. These two systems simply give finer graduation in sizes than the fractional-inch system, the letter system having 26 drills ranging in size from 0.234 to 0.413 in., and the

wire-gage system having 80 drills ranging in size from 0.228 to 0.0135 in. These drills are commonly used by machinists and jewelers and would seldom be needed in the farm shop, except possibly a very few selected sizes of wire-gage drills to be used as tap drills for tapping small machine-screw threads.

Drill chucks A Jacobs 3-jaw chuck, which is tightened and loosened with a geared key, is more or less standard equipment for holding and driving straight round shank drills. It is widely and satisfactorily used

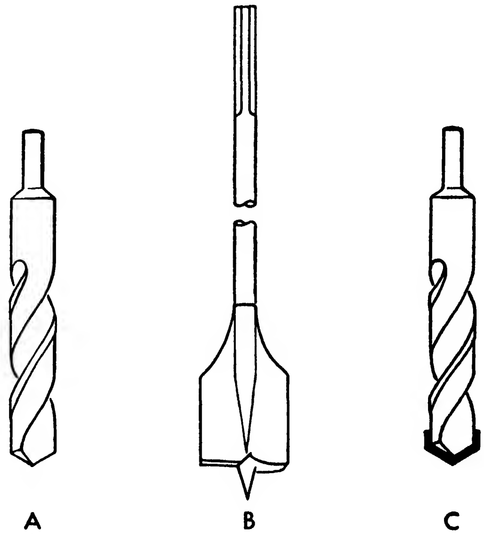


Fig. 12-30. Types of drill bits often used in electric drills: *A*, twist drill with 1/4-in. shank for use with small electric drills in drilling wood; *B*, flat wood-boring bit; *C*, Carbide-tipped drill for drilling holes in concrete and masonry.

on drilling machines in the farm shop. A similar but less expensive type of 3-jaw chuck is locked and unlocked with a hexagon key or setscrew wrench instead of a geared key. Chucks for small hand drills are tightened and loosened by hand.

Chucks are attached to drill presses and other drilling machines in different ways. One common method is to have the chuck threaded to screw onto matching threads on the end of the drill-press spindle. Another common method is to have the chuck fitted with a tapered shank with a flat tang on the end to fit into a matching socket in the end of the drill-press spindle.

7. DRILLING HOLES IN METAL

A properly sharpened drill is the first requirement for satisfactory drilling. A drill that is not properly ground will do poor work; it

will cut slowly; it will require excessive effort to turn it; and there will be danger of breaking it. Drills require frequent grinding if they are used much. Anyone who expects to use drills with satisfaction or profit to himself should therefore become proficient in grinding them. See Chap. 7, "Sharpening and Fitting Tools," pages 224 to 230, for information on drill sharpening.

Center punching Always start a twist drill in a deep center-punch mark—one that is big enough to take the point of the drill. Otherwise, the drill will likely "wander" and drill the hole off center or not exactly in the right place. In doing accurate work, first mark the location for the hole by the intersection of two scratch lines. Make the lines with a

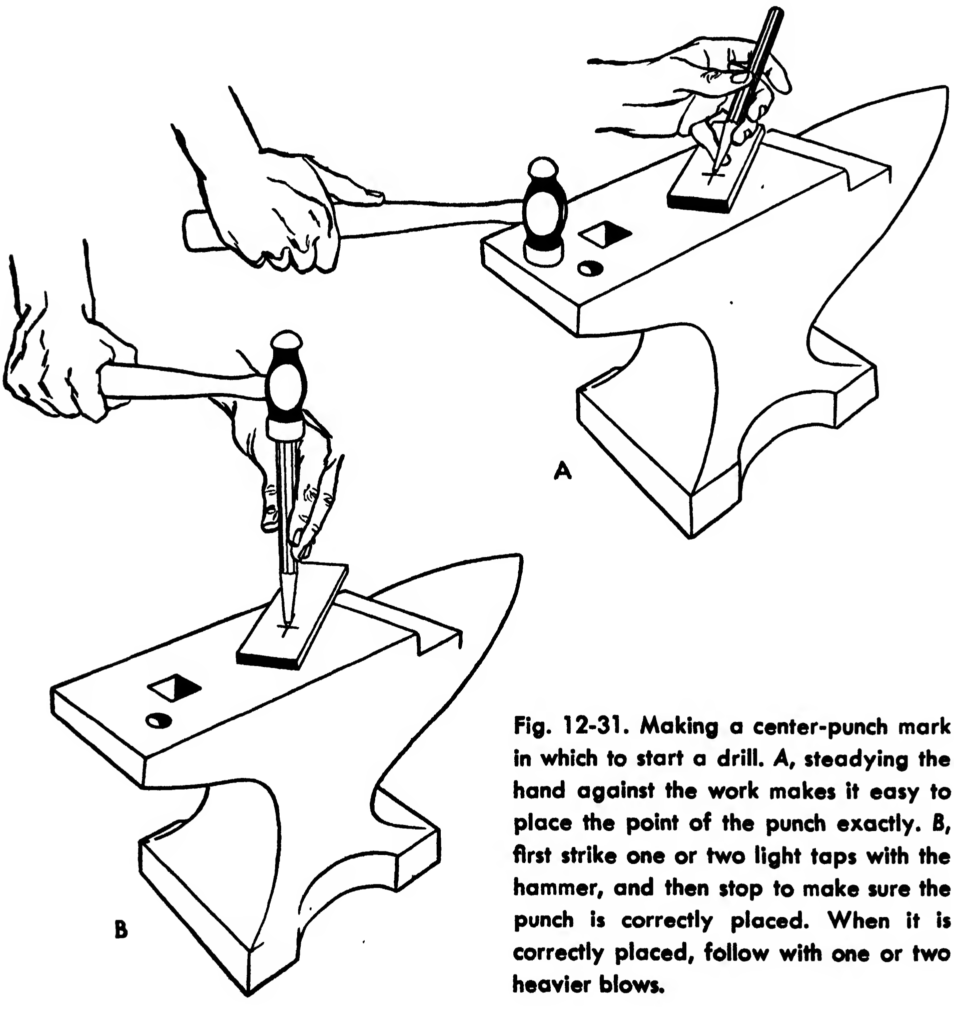


Fig. 12-31. Making a center-punch mark in which to start a drill. A, steadying the hand against the work makes it easy to place the point of the punch exactly. B, first strike one or two light taps with the hammer, and then stop to make sure the punch is correctly placed. When it is correctly placed, follow with one or two heavier blows.

scriber or scratch awl and a square (see Fig. 12-31). To locate the center of a small rectangular piece, simply draw diagonals from the opposite corners. The intersection of the diagonals will be the center. A very satisfactory scriber can be made by grinding the end of an old saw file to a needle point.

After making the cross lines, place a large deep center-punch mark at their intersection. Carefully place the point of the center punch exactly at the intersection. This may be done easily by steadying the hand against the work, while the point is lowered and moved about

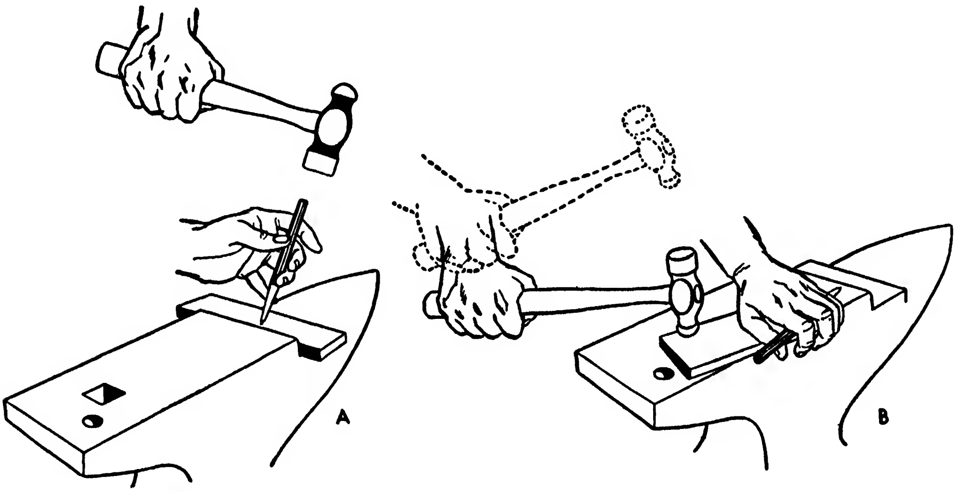


Fig. 12-32. In the event that a punch mark is not properly located, it may be changed by driving the punch at an angle, as at *A*, or it may be hammered out with a ball-peen hammer, as at *B*, and a new one made. Still another method is to turn the bar over and make a punch mark and drill from the other side.

into position (see Fig. 12-31). First strike a light tap with the hammer, and then inspect to see if the mark is started in exactly the right place. If so, replace the punch and strike one or two heavy blows to make a large, deep mark; and then proceed with the drilling. In case the punch mark is not started in the right place, however, shift it by driving the punch at an angle; or hammer it out with a ball-peen hammer and make a new mark (see Fig. 12-32). On some jobs it is possible to relocate the mark on the opposite side of the material and start over.

Selecting the proper size drill bit Be sure to use a drill of the right size. The size of a new drill may be determined from the numbers

stamped on the shank. After long use, these numbers may not be legible, particularly if the drill has been allowed to slip in the drill chuck. In such a case, the size of the drill may be quickly determined by measuring with a caliper rule (Fig. 14-7*B*) or by trying it in a drill gage, or in a drill stand or holder with the various drill holes labeled as to size. A drill gage is simply a piece of steel with various sizes of holes drilled in it and marked.

A drill stand or holder not only keeps drills in order for easy selection of the right size, but it also helps keep small drills from getting

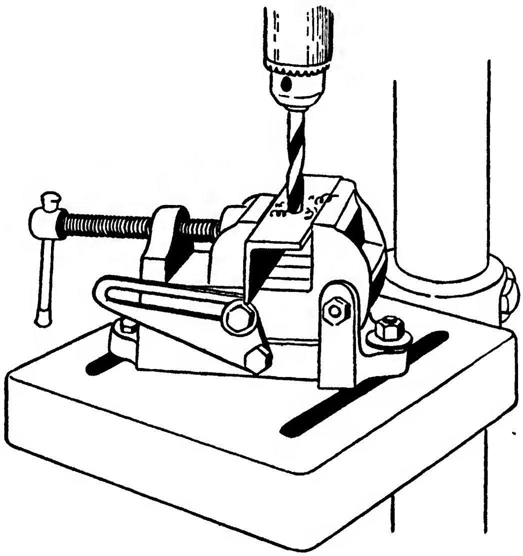


Fig. 12-33. A drill vise is especially good for holding small parts while being drilled.

lost. A drill stand or holder may be bought, or one may be made in the shop by drilling holes in metal or hard wood to receive the various sizes of drills.

Fitting the drill into the drill chuck Insert the drill carefully into the chuck and tighten it securely to prevent slipping. Be sure that the drill and the chuck match as to type. Do not try to fit a flat-sided blacksmith's drill or a drill with a square tapered shank into a 3-jaw chuck, for example, or a straight round shank drill into a blacksmith's drill chuck. Attempting to use a drill in the wrong kind of chuck will result in damage to the drill or the chuck or both. In case the shank of a drill has become marred or roughened by slipping in the chuck, smooth it with a fine file or grinding wheel.

Holding work on the drill table; safety in drilling Do not attempt to hold small pieces by hand on the drill table while drilling, not even when using a hand-operated blacksmith's post drill. The drill might catch in the work and throw it off the table, possibly breaking the drill or injuring the operator or both, and possibly damaging the work also. It is best to use a drill vise for holding small parts on the drill table (see Fig. 12-33). Stop bolts located in slots in the table can often be used to advantage to keep work from turning while being drilled (see Fig. 12-35).

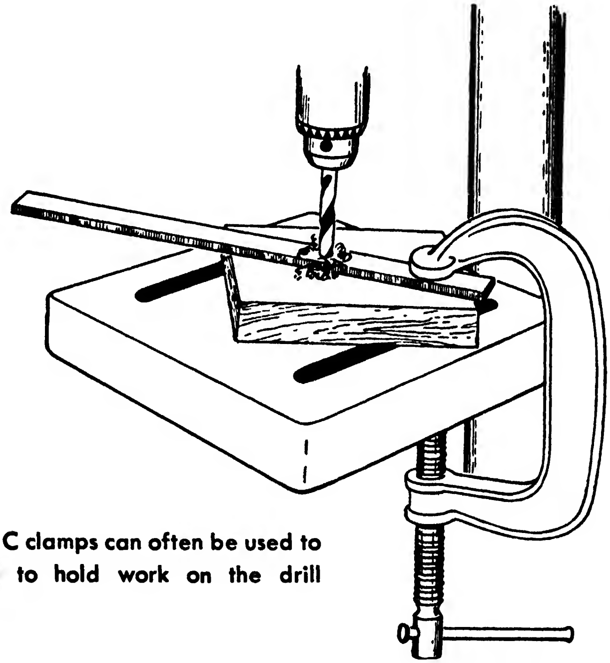
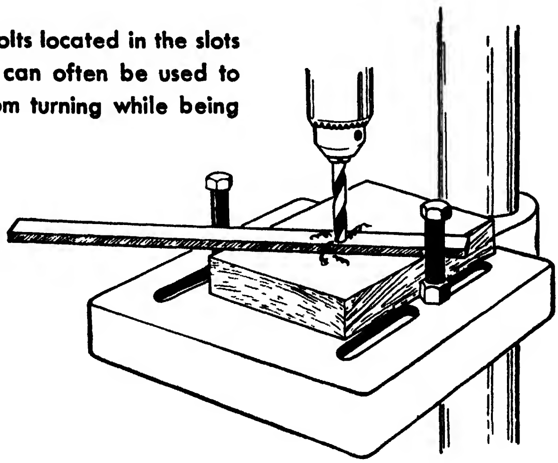


Fig. 12-34. C clamps can often be used to advantage to hold work on the drill table.

Fig. 12-35. Stop bolts located in the slots of the drill table can often be used to keep the work from turning while being drilled.



Use a hardwood block under the work on the drill table whenever there is a possibility that the drill may go through and drill into the table.

Round rods or pipes may be kept from rolling on the drill table by use of a wooden block with a V notch sawed in it (see Fig. 12-36).

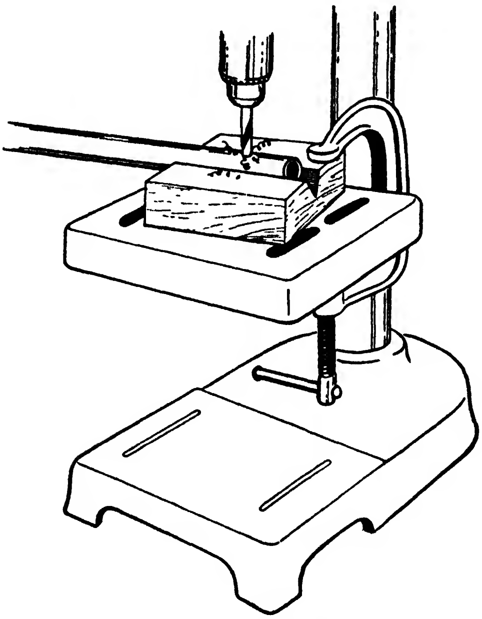


Fig. 12-36. A V notch sawed in a block of wood is useful to keep round pieces from rolling on the drill table while holes are being drilled in them.

Drilling at proper speeds and pressure If the drill press has adjustable speeds, select a speed suited to the kind and size of drill to be used and the material to be drilled. See Table 12-1. The drill should run fast enough to give rapid cutting, but not so fast that the drill squeaks and fails to bite into the metal, nor so fast that the drill overheats. In general, turn small drills fast, and large ones slow. With a little experience a good operator soon learns to know the correct drilling speed.

Use enough pressure on the drill to give moderate to fast uniform cutting, yet not so much as to cause the drill to gouge or catch in the work.

Lubricating the drill When drilling mild steel, apply lard oil or a good cutting or threading oil as soon as the drill is centered in the center punch mark and starts to cut. Keep oil on the cutting end of the drill, applying more as required as the drilling proceeds. Turpentine or kerosene is recommended for drilling aluminum and also hard steel or other very hard materials. No lubricant is required for drilling cast iron or brass.

A lubricant helps keep the drill cool, and makes it cut easier and smoother. Also, if a good lubricant is used where needed, the drill will stay sharp much longer. Always keep a small squirt can of suitable cutting oil handy when drilling.

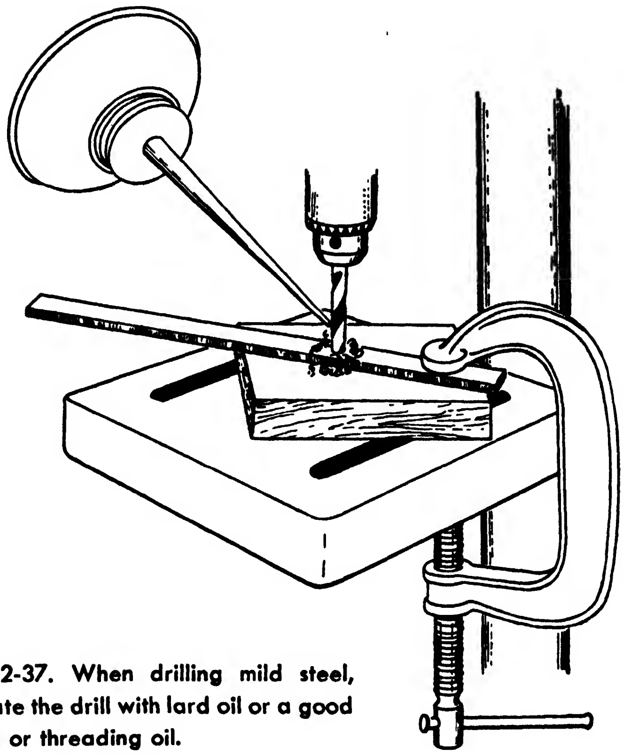


Fig. 12-37. When drilling mild steel, lubricate the drill with lard oil or a good cutting or threading oil.

Preventing drill breakage Most drill breakage occurs just as the drill goes through the work. To prevent such breakage, be sure the work is held securely and release the pressure slightly on the drill just as it goes through. Gouging and breaking are often caused by (1) improper sharpening, (2) too slow a speed, (3) too much pressure on the drill, or (4) not holding the work securely, or a combination of these.

Drilling large holes; enlarging holes When a large hole is to be drilled with a light drill press, it is often easier to drill through first with a small drill and then follow with a drill of the desired size. It is important that the work be securely held and that a moderate, even pressure be used in drilling the second hole in order to prevent gouging. Where extreme accuracy is required in locating a large hole, a very small one may be drilled through first to serve as a pilot hole for keeping the large drill centered.

If a large drill of the desired size is not available, and if a tapered hole will do, a hole may be drilled somewhat smaller than desired and then enlarged with a repairman's taper reamer (see Fig. 12-38).

Such a reamer is also valuable in assembling machinery when bolt holes in metal parts do not quite line up. A few turns with the reamer will usually allow the bolt to go in. This type of reamer is commonly made with a square taper shank for use in a carpenter's brace.

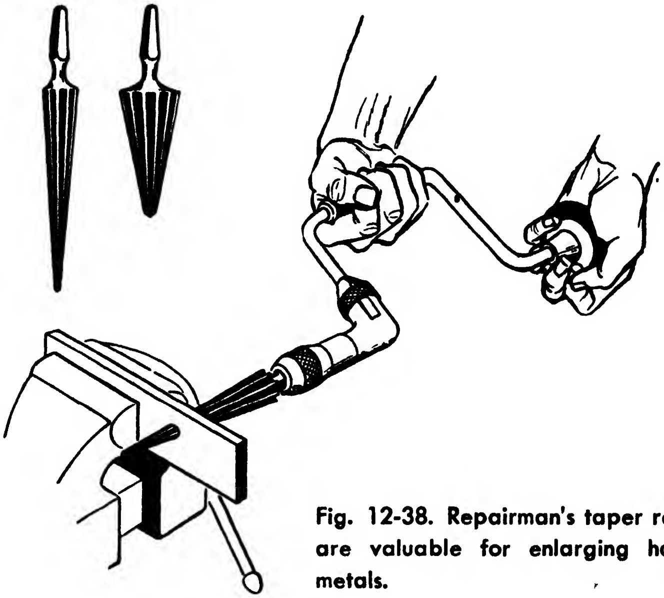


Fig. 12-38. Repairman's taper reamers are valuable for enlarging holes in metals.

Drilling holes in thin metal There is a tendency for a drill to catch and gouge in drilling thin metal and for the metal to become distorted as the drill goes through. These difficulties may be reduced by using a light feed pressure and being sure that the drill is turned at as high a speed as is needed. It is often possible to avoid these troubles by clamping the thin metal between two pieces of hardwood and drilling through both wood and metal.

Countersinking Holes in metal may be countersunk to receive flathead or oval-head screws by using a metal-cutting countersink, or even a regular twist drill. A regularly ground twist drill will not give quite the right angle to the countersunk hole, however, and it is likely to chatter, or possibly even catch and gouge. Probably a better way is to grind a drill specially for countersinking and to keep it for this purpose. To do this, grind the lip angle to about 41 deg instead of the usual 59 deg and grind the front edges of the lips blunt as shown in Fig. 7-46.

Another way of countersinking, using only regularly ground twist drills, is to drill first with the large drill, drilling just deep enough for the screwhead, and then to drill through with the small drill.

Points on drilling

1. Always use a properly sharpened drill.
2. Insert the drill carefully in the chuck, being sure the drill and the chuck match.
3. Do not allow the drill to slip in the chuck, as this may damage both the drill and the chuck.
4. Start the drill in a deep center-punch mark, accurately located.
5. Use lard oil or a cutting oil when drilling in steel.
6. Hold the work securely on the drill table.
7. Use a block of wood on the drill table to prevent the drill from going through the work and into the table.
8. Use a suitable drilling speed. In general, turn small drills fast, and large ones slow.
9. Use a light, even pressure just as the drill goes through the work to lessen the danger of catching or gouging and breaking the drill.
10. Keep round rods and pipes from rolling on the drill table by holding them in a V block.
11. A taper reamer is useful for enlarging holes, and in aligning holes in machine parts.
12. To prevent catching and gouging when drilling thin metal, clamp it between pieces of hardwood and drill through both wood and metal.
13. A drill stand enables one to select the desired size of drill quickly. It also helps to keep drills from getting lost.

8. BENDING COLD METAL

Although it may be necessary to heat large pieces of iron or steel to bend them satisfactorily, many small pieces can be bent better and more easily cold.

Bending in the vise With a good machinist's or blacksmith's vise, rods and bars up to $\frac{5}{16}$ or $\frac{3}{8}$ in. thick can be readily bent. Many appliances and repairs can be made with stock of this size and smaller.

Care should be exercised, of course, not to do too heavy hammering or bending in a small vise, lest the vise be damaged or broken.

An easy way of making a small bend in strap iron or a thin bar is to bend the stock around a pipe or rod of suitable size. Simply clamp the stock beside a pipe or rod in a vise and bend it by pulling and hammering (see Fig. 12-39).

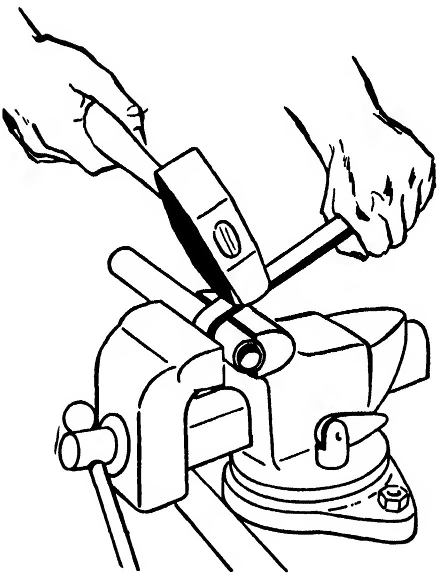


Fig. 12-39. To make a short bend or a small eye in a thin bar, clamp it against a pipe or rod held in a vise, and then bend it around the pipe or rod.

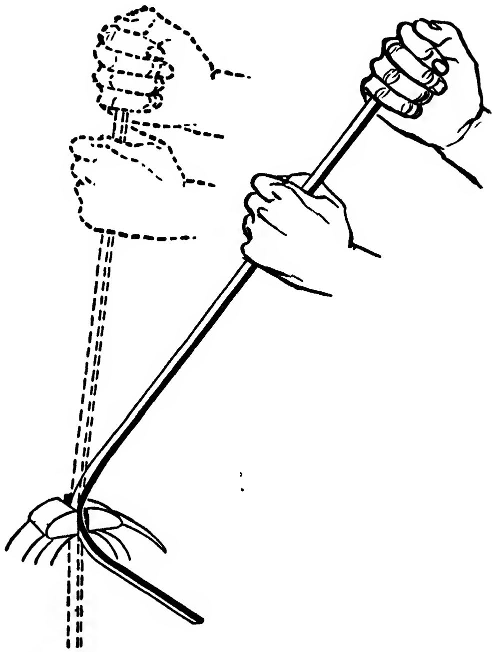


Fig. 12-40. To make a smooth, gradual bend of large size, clamp the bar loosely in a vise and bend it a little; then slip the bar through a little farther and bend more, continuing until the desired curve is made.

To make a uniform bend of large size, slip the end of the stock between the jaws of a vise that are loosely adjusted, and then pull. After the bar is bent slightly, release the pull and slip the bar through the jaws about ½ in. further, and then pull again (see Fig. 12-40). In this manner make a series of short bends, thus giving a reasonably smooth bend of rather large curvature.

A bar that is too heavy or too short to be bent by hand may be

clamped in a vise and bent by hammering and pulling or by pulling on a pipe slipped over the end (see Fig. 12-41).

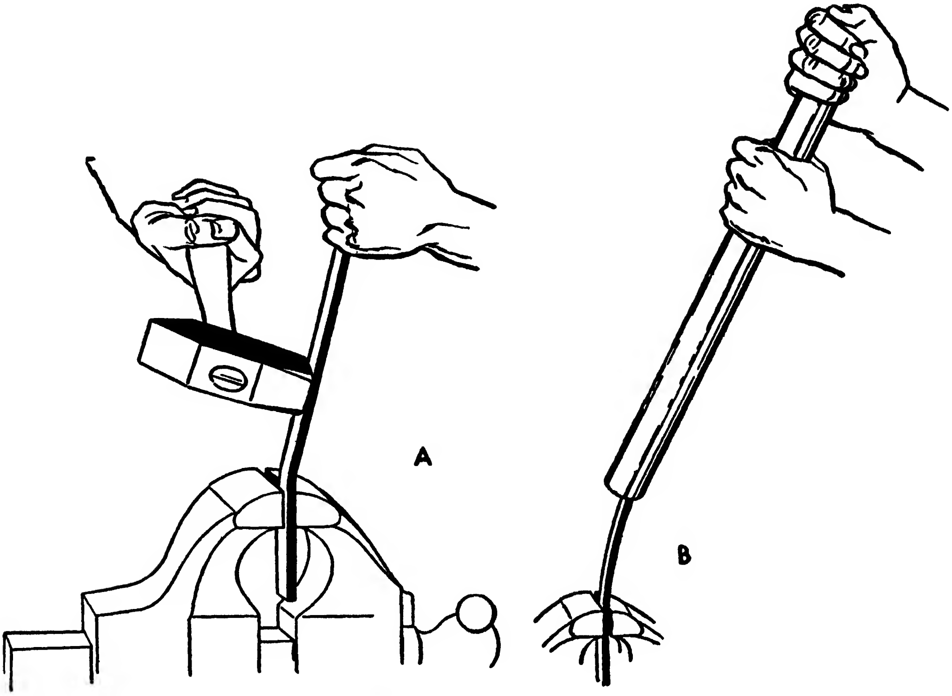


Fig. 12-41. Short bars or bars too heavy to be bent by hand may be bent by hammering, as at *A*, or by pulling on a pipe slipped over the end, as at *B*.

Twisting cold metal Small bars of iron or other metals are easily twisted cold, using the vise and a wrench, or a pair of wrenches, or a pair of tongs. Methods for twisting cold metal are much the same as for twisting hot metal, except for the heating. See Chap. 14, "Farm Blacksmithing," page 449.

9. RIVETING

Riveting offers a convenient and easy method of securely holding metal parts together. Many repairs can be made on machinery and equipment by riveting.

The procedure in riveting is simply to drill holes through the parts to be held together, insert a soft steel rivet, and then hammer it tightly in place. For some work, it is better to heat the rivets and then

insert them and hammer them down while hot; but for general farm shopwork, cold riveting is quite satisfactory.

To hammer down a rivet and form a head on it, first strike one or two heavy blows with the flat face of the hammer, and then finish with lighter blows, preferably with the ball peen of the hammer (see Fig. 12-42). Where available, a rivet set may be used to form a neat round head on a rivet.

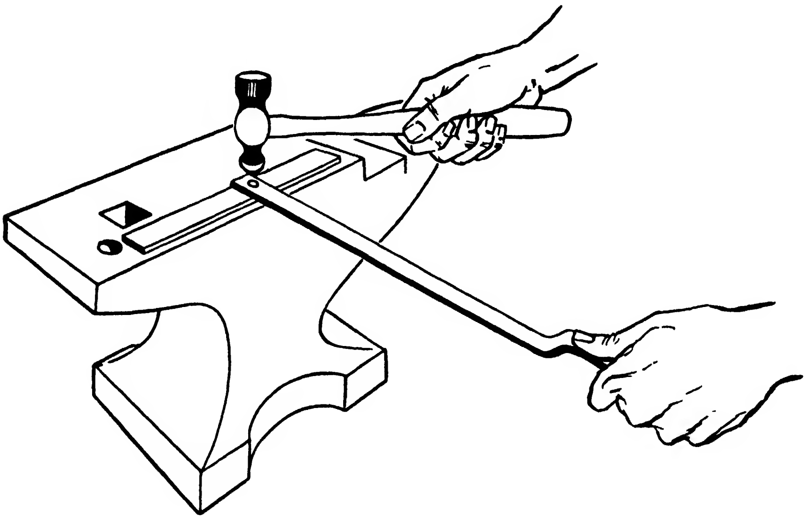


Fig. 12-42. A neatly rounded head may be formed on a rivet by first striking a few medium-heavy blows and then finishing by light peening with a small ball-peen hammer.

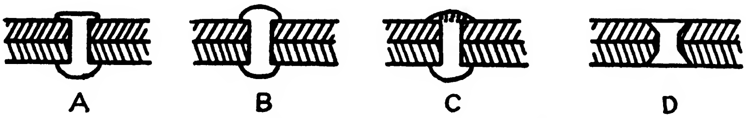


Fig. 12-43. Methods of heading rivets: *A*, flat head made by straight hammering; *B*, head rounded with rivet set; *C*, head rounded with small ball-peen hammer; *D*, ends of rivet hammered into countersunk holes with ball-peen hammer.

If it is desired to fasten pieces together and not have rivet heads protruding from the surface, countersink the holes as indicated in Fig. 12-43*D*. Then use rivets without heads, and peen the ends into the countersunk holes.

Cutting rivets to length A good way to cut a rivet to the desired length is to clamp it in a vise with the head up and then shear it off

with a cold chisel. To keep the rivet from flying off and becoming lost as it is cut, hold the chisel near the cutting end with the thumb and first fingers, allowing the palm of the hand to cover the rivet (see Fig.

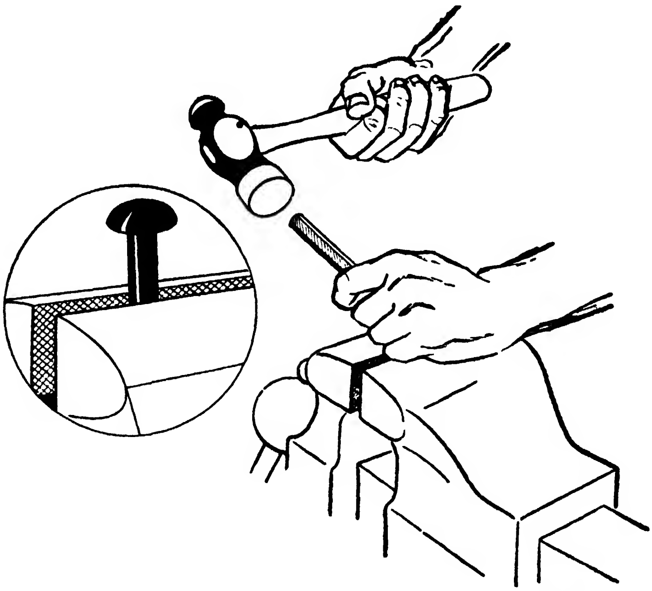


Fig. 12-44. Rivets may be cut to length easily by clamping in a vise and shearing with a sharp cold chisel. Placing the hand over the top of the rivet keeps it from flying away and being lost as it is cut off.

12-44). Rivets may also be cut with heavy pincers, with small bolt cutters, or with a hack saw.

10. THREADING

Bolts and threaded fittings are widely used on all kind of machinery. Equipment for threading bolts, nuts, rods, and pipes, and ability to use it, will greatly increase the scope of repair work that can be done in a shop. Such equipment will also make possible the construction of many handy and useful appliances.

Threads are cut on a rod or bolt by a small hardened-steel tool called a *die*. The die proper, which is usually adjustable, is held in a handle called a *stock*. The tool used for cutting threads inside a hole, as in a nut that screws on a bolt, is called a tap (see Fig. 12-45). A set of taps and dies is called a *screw plate* (see Fig. 12-46).

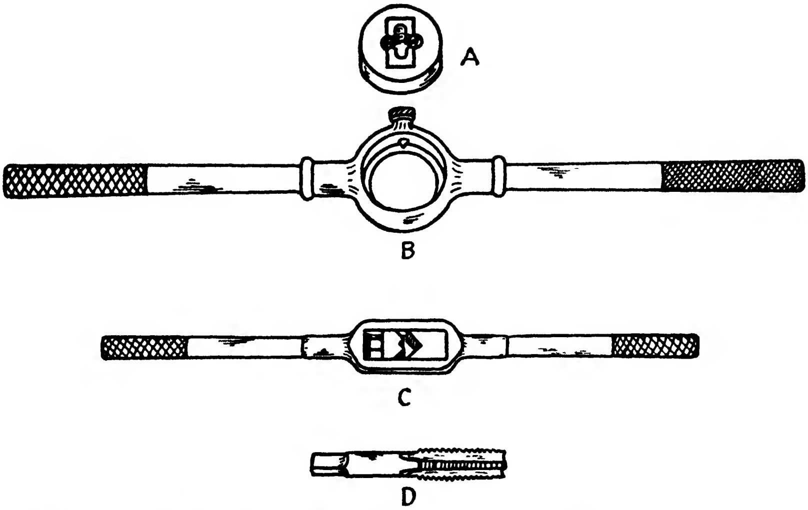


Fig. 12-45. Threading tools: *A*, die; *B*, stock for holding die; *C*, tap wrench; *D*, tap.

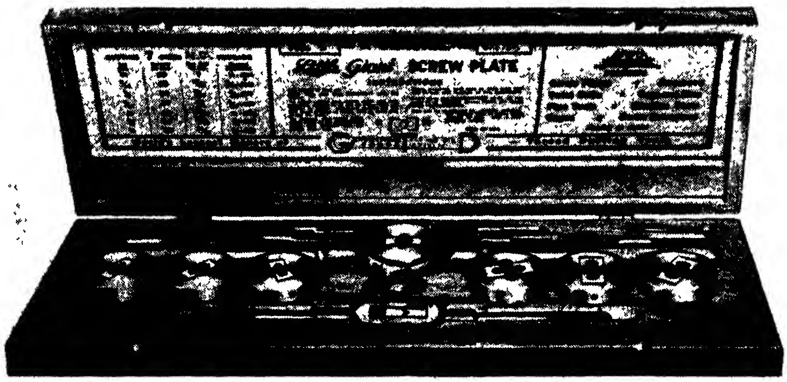


Fig. 12-46. A set of taps and dies, known as a *screw plate*, is a valuable asset in the farm shop. (Greenfield Tap and Die Corporation)

Comparing kinds of threads

1. Bolt threads Bolt threads are of two general standards, *National Coarse* (NC) and *National Fine* (NF). The coarse threads are commonly used on bolts in farm machinery, and the fine threads on bolts in automobiles, trucks, tractors, and engines (although not exclusively) and on other machines where extra-strong steel bolts are used. It is common practice to indicate the size of a thread by two numbers, the first being the diameter of the bolt and the second the number of threads per inch. For example, a $\frac{3}{8}$—16 thread would be for a $\frac{3}{8}$-in. bolt and would have 16 threads per in. The fine threads are of the

same general shape as the coarse ones, but they are smaller and there are more of them per inch. Nuts with fine threads may be drawn up tighter than those with coarse threads, and they will not shake loose so easily. The NC threads were formerly known as *United States Standard* (USS), and the NF threads as *Society of Automotive Engineers* (SAE).

2. *Machine-screw threads* Machine screws are really small bolts, under ¼ in. in size. The threads used on machine screws are of the same general shape as bolt threads, but they are much smaller and there are more of them per inch. Machine screws are used in small machines and apparatus like small motors, electric fans, and carburetors. The size of a machine-screw thread, or a tap or die for cutting it, is designated by two numbers, in the same manner as bolt threads, the first number being the size of the screw and the second the number of threads per inch. For example, an 8—32 thread is for a No. 8 screw and has 32 threads per inch.

3. *Pipe threads* Pipe threads, known as Briggs standard threads, or simply as standard pipe threads, are used on pipes and pipe and tube connections on engines, motors, and machines. Pipe threads have a slight taper of 1/16 in. per in. of length. Since the threaded end of a pipe is tapered, the farther it is screwed into a fitting, the tighter the joint becomes. This makes it possible to make a tight joint without having any tension or end pull on the pipe. Bolt threads are straight or cylindrical and not tapered. A nut or a bolt does not tighten, therefore, until it is drawn up against the part being held by the bolt.

Pipe threads are much larger than the corresponding size of bolt threads, owing to the system of indicating pipe sizes. The size of a pipe is designated by its inside diameter—not its outside diameter. A ½-in. bolt die cuts threads on the outside of a rod or bolt whose *outside* diameter is ½ in.; and ½-in. pipe die cuts threads on the outside of a pipe whose *inside* diameter is ½ in. The pipe die, therefore, is much larger.

Selecting bolt-threading equipment for the farm shop A set of taps and dies that will cut both NC and NF threads in sizes from ¼ in. to ½ in., inclusive, ⅛-in. standard pipe threads, and machine-screw threads in 4—36, 6—32, 10—24, 10—32, and 12—24 sizes, would be practically ideal. Individual taps and dies to cut one or two larger bolt threads, say ⅝ and ¾ in., might be justified in some shops, but would seldom be needed in the average shop.

Probably the smallest set that would be recommended for a farm shop would be one that would cut NC threads in sizes from 1/4 to 1/2 in. The taps and dies for cutting machine-screw threads would occasionally be useful for repairing water faucets, locks, guns, electric fans, small motors, carburetors, and similar small delicate equipment.

Determining the size and kind of die to use In threading a rod to make a bolt, or in rethreading a bolt, be sure to select the proper size and kind of die. The size of rod or bolt may be easily and accurately measured with a caliper rule or, by careful work, with an ordinary rule. With a little practice, the kind of threads on a bolt (whether fine or coarse) can be determined at a glance.

The number of threads per inch on a bolt, may be determined by

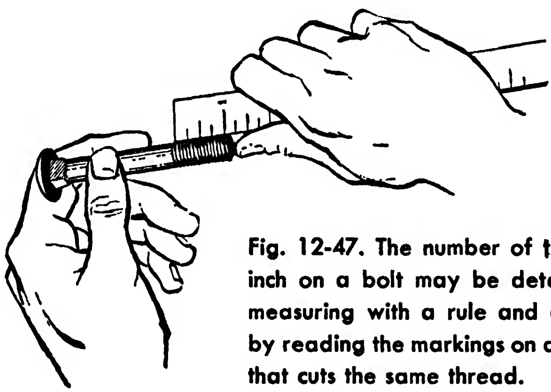


Fig. 12-47. The number of threads per inch on a bolt may be determined by measuring with a rule and counting or by reading the markings on a tap or die that cuts the same thread.

holding the bolt against a tap from a set of taps and dies, to see if the threads on the bolt and tap correspond. If they do, then the number of threads per inch may be read from the markings on the tap. Likewise, dies from the set may be tried on the bolt until one is found that fits perfectly and the threads per inch and the size of bolt determined from the markings on the die. The number of threads per inch can also be determined by placing a rule against the threaded end and counting the threads for 1 in. (see Fig. 12-47). In the more completely equipped shops, thread-pitch gages are used to determine the number of threads per inch on bolts.

Threading a rod or a bolt To thread the end of a rod, first taper it slightly by filing, hammering, or grinding so that the die will start on easily (see Fig. 12-48). Do not make the taper too short and blunt. Be sure the proper size and kind of die has been selected, and then

start it on the rod by exerting equal pressure on the two handles of the stock and turning. Be careful to start the die on straight (see Fig. 12-49).

As soon as the die starts to cut and feed itself onto the rod, lubricate the die by applying lard oil or threading oil (see Fig. 12-50). This will

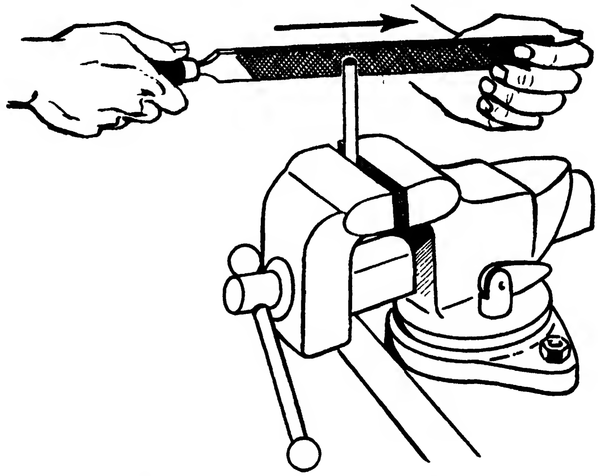


Fig. 12-48. To enable the die to start easily, taper the end of the rod slightly by filing grinding, or hammering. Do not make the taper too blunt.

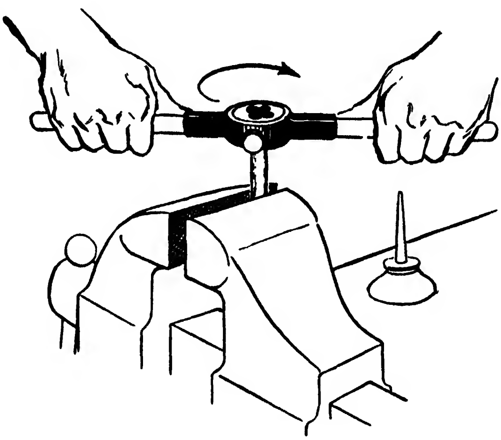


Fig. 12-49. Be sure to start the die straight, exerting equal pressure on the two handles.

make the die cut more easily, and cut a smoother thread, and the die will stay sharp and last much longer.

Turn the die round and round in the forward direction without backing up until the thread is finished. Apply more oil as may be required. If chips and cuttings tend to collect in the die and clog it, stop

and punch them out with a small nail, a wire, or a small piece of wood. If allowed to accumulate, the chips may cause rough or torn threads. When the thread is cut as far as desired, simply screw the die back off. Shake the cuttings from the die by tapping the end of the stock against

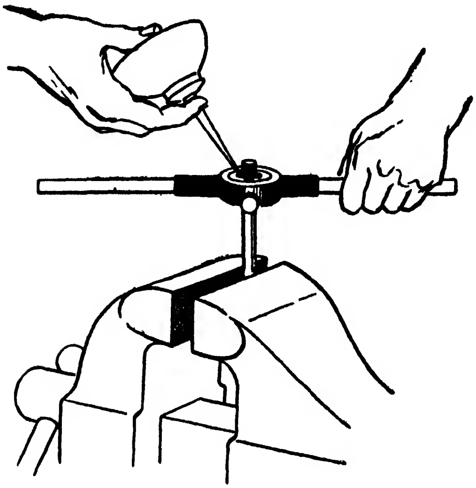


Fig. 12-50. When threading steel rods or bolts, always lubricate the die with lard oil or a threading oil. Oil makes the die turn more easily, cut smoother threads, and last longer.

the bench top. Before putting the die away, be sure it is well cleaned and that any excess oil is wiped off.

Tapping threads in a hole or nut If a threaded hole is to be made in a piece of metal, a hole of suitable size must first be drilled. The hole

TABLE 12-2. Threads per Inch and Tap Drill Sizes for Bolt Threads: 1/4 to 3/4 in.

Size of tap	National Coarse		National Fine	
	Threads per inch	Tap drill size	Threads per inch	Tap drill size
1/4	20	3/16	28	7/32
5/16	18	1/4	24	1/4
3/8	16	5/16	24	5/16
7/16	14	11/32	20	25/64
1/2	13	13/32	20	29/64
9/16	12	15/32	18	33/64
5/8	11	17/32	18	37/64
3/4	10	21/32	16	11/16

must be somewhat smaller than the size of the bolt to be screwed into it, usually $\frac{1}{16}$ in. smaller for bolts $\frac{1}{4}$ to $\frac{1}{2}$ in. in size.

Probably the best method to determine the exact size of drill to use is to refer to a table, such as Table 12-2, 12-3, or 12-4. In the absence of such a table, a hole somewhat smaller than the bolt may be drilled in a piece of scrap material and the tap tried in it. If the hole does not prove to be the proper size, try a size larger or smaller as may be required.

TABLE 12-3. Threads per Inch and Tap Drill Sizes for Bolt (or Machine Screw) Threads Smaller Than 1/4 In.

Size of tap	Outside diameter, in.	National Coarse		National Fine	
		Threads per inch	Tap drill size, No.	Threads per inch	Tap drill size, No.
0	0.060	..	..	80	56
1	0.073	64	53	72	53
2	0.086	56	50	64	50
3	0.099	48	47	56	45
4	0.112	40	43	48	42
5	0.125	40	38	44	37
6	0.138	32	36	40	33
8	0.164	32	29	36	29
10	0.190	24	25	32	21
12	0.216	24	16	28	14

TABLE 12-4. Tap Drill Sizes for Pipe Taps (Briggs Standard)

Size of Tap	Size of Drill
1/8	21/64
1/4	7/16
3/8	9/16
1/2	23/32

After a hole of the proper size has been drilled, start the tap in the hole by applying pressure and turning it slowly. A good way is to use only one hand, pushing firmly with the palm against the center of the tap wrench, and giving it a slow twist with the wrist (see Fig. 12-51*A*). Be particularly careful to start the tap straight.

After the tap starts, turn it by pulling with equal force on the two ends of the tap wrench (see Fig 12-51*C*). Always use lard oil or threading oil on the tap when cutting threads in steel. Turn the tap until the tapered part is all the way through the hole and the tap turns easily. Then stop and unscrew it from the hole.

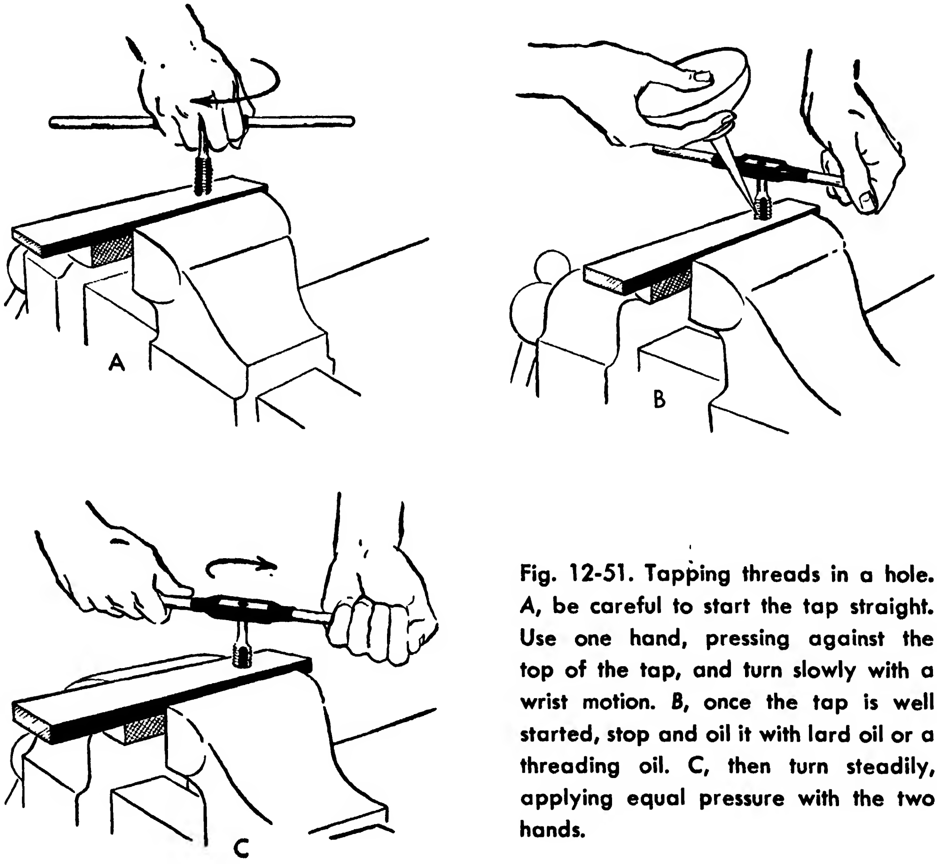


Fig. 12-51. Tapping threads in a hole. *A*, be careful to start the tap straight. Use one hand, pressing against the top of the tap, and turn slowly with a wrist motion. *B*, once the tap is well started, stop and oil it with lard oil or a threading oil. *C*, then turn steadily, applying equal pressure with the two hands.

Making a bolt A very simple way to make a bolt is to cut off a rod to the desired length, thread both ends, and screw on nuts. With a small assortment of nuts and a few different sizes of rods, one can easily make a bolt for almost any occasion or emergency. Moreover, the bolt is practically as good as a bolt that is bought and usually just as cheap or cheaper. If desired, one of the nuts may be riveted or welded onto the rod to prevent loosening.

Rethreading a bolt Threads on bolts often become battered, and it is then difficult or impossible to screw nuts onto them. Such battered

threads can usually be renewed by simply running a regular die down over them in the same manner as in cutting new threads. The use of a rethreading die is usually simpler, however, if such a tool is at hand. Rethreading dies, which usually come in sets, are six-sided one-piece dies and may be screwed onto bolts with a wrench in the same manner as ordinary nuts. To use such a die, simply start it onto the threaded end of the bolt with the fingers, apply lard oil or a threading oil, and screw it on with a wrench. When it has been screwed down to the end of the threads, screw it back off the bolt.

Points on cutting threads

1. Taper the end of the rod slightly before starting the die. Do not make the taper too blunt. Use a file, a hammer, or a grinder.
2. Start a tap or a die slowly and carefully so as to get it started straight.
3. Use equal pressure on the handles of the stock or tap wrench.
4. Always use lard oil or a threading oil when threading steel. It will make the tool cut more easily and smoothly and last longer.
5. Do not back up or reverse the taps and dies until the thread is complete.
6. If chips and cuttings tend to clog the tool, remove them with a small nail or wire or piece of wood.
7. Be sure to drill the proper size of hole before tapping. A hole that is too small can be easily and quickly enlarged with a taper reamer.
8. An easy way to make a bolt is to thread both ends of a rod and use nuts on both ends.
9. Remove the cuttings and wipe off excess oil before putting taps and dies away.
10. Battered threads on a bolt may be renewed by using either a small rethreading die or a regular die.

JOBS AND PROJECTS

1. Make a scriber or metal-marking tool by grinding the end of an old saw file to needle point.

2. If not already done, assemble the cold-metal working tools about your shop or home, and arrange a small cabinet or tool rack for keeping them. Sharpen the cold chisels and punches and other cutting tools if they need sharpening.

3. Look through shop manuals, books, and bulletins, and make a list of small appliances and jobs, involving cold-metal work, that would be useful around your home or farm.
   Select a few of these and make them in the shop. Plan your work carefully before starting a job.

4. A check list of small articles and appliances involving cold-metal work includes:

Hasp	Small clevis
Chain repair link	Corner irons for window screens
Tool-grinding gage	Small gate hook
Endgate rod washer	Bolt and nut
Shoe scraper	Flower-pot holder or stand
Wire splicer	Lamp bracket
Shelf brackets	Door antisag rod
Endgate rod nut	

5. Look about your home or farm, and make a list of repair jobs to machines or equipment that could be done with only such work as drilling, riveting, hack sawing, filing, punching, and cutting with a cold chisel. Bring two or three such jobs to the shop and do them.

6. Make a trash burner out of an old oil drum as follows: With a slitting chisel or a cold chisel cut out one end. Cut a draft opening about 4 by 6 in. in the side, near the other end. Set the drum with the open end up, and it is ready for use.

13 THE METALWORKING LATHE

1. Making Accurate Measurements
2. Turning between Centers
3. Turning Tapers
4. Cutting Threads
5. Chucking Work in the Lathe
6. Turning Wood on a Metalworking Lathe
7. Grinding Cutter Bits for the Lathe

THE METALWORKING lathe is used for turning, boring, facing, threading, making parts, truing and smoothing cylindrical surfaces like motor and generator commutators, and many special jobs in connection with the maintenance and repair of tractors, automobiles, and machines. Lathes are used in most automotive repair shops, many school shops, and a few farm shops. They are rather expensive, and for satisfactory work they require skilled and careful operation. At first students of farm shopwork seldom realize the care and extreme precision required in measuring and doing work on the lathe. Instead of measuring in eighths, sixteenths, and thirty-seconds of an inch as in most farm shopwork, lathe work requires measuring in thousandths of an inch.

A lathe holds the work securely and turns or rotates it very accurately against a cutting tool mounted in a tool carriage. Many different speeds are provided for the spindle so that a suitable speed may be quickly selected for various sizes and kinds of material to be turned. The cutting tool may be fed lengthwise or crosswise by hand, or

by power at various speeds. The depth of cut of the tool is easily set by means of a micrometer adjustment.

The size of a lathe is designated by the diameter of the largest work it will turn and the length of the bed. A 9- or 10-in. lathe with a 3-ft

Fig. 13-1. The metalworking lathe is used for many special repair jobs on farm machines and equipment. (South Bend Lathe Works)

bed mounted on a sturdy bench is adequate for most farm shopwork. A ⅓ hp motor is usually recommended for a lathe of this size.

1. MAKING ACCURATE MEASUREMENTS

The measuring tools needed for lathe work are an accurately graduated steel rule, called a *scale* by machinists, inside and outside calipers, and a micrometer caliper. Wood rules are not accurate enough for making measurements in lathe work.

Measuring with calipers Accuracy in measuring with calipers depends upon a sense of feel, which can be developed with practice, and upon careful setting of the calipers on a scale. Methods of setting calipers are shown in Figs. 13-2 and 13-3. In measuring, the calipers

should be held very lightly in the fingers so that you can tell when they just touch the part being measured. Care must be taken also to keep them exactly perpendicular or on a true diameter when measuring round stock. When properly set, the weight of a pair of calipers will be

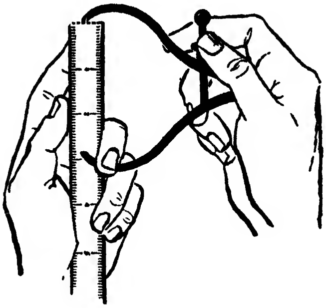


Fig. 13-2. Setting or reading an outside caliper. (South Bend Lathe Works)

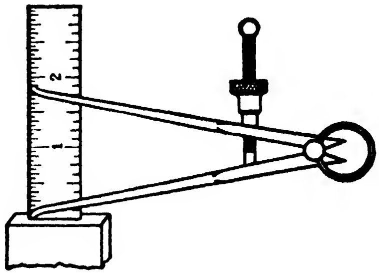


Fig. 13-3. Setting or reading an inside caliper. (South Bend Lathe Works)

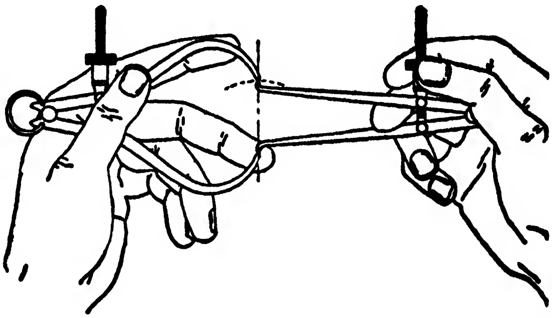


Fig. 13-4. Transferring a measurement from one caliper to another. In a similar manner a measurement may be transferred between a micrometer caliper and a plain caliper. (South Bend Lathe Works)

enough to make them slip over the part being measured. Never force them.

Reading and using a micrometer caliper The smallest graduation on the barrel of a micrometer caliper (see Fig. 13-5) is 0.25 in., and is the distance the spindle moves in one turn. Every fourth division mark is longer and is numbered to indicate tenths of an inch ($4 \times 0.025 = 0.100$, or $\frac{1}{10}$ in.). The beveled edge on the thimble is divided into 25 parts, each division representing $\frac{1}{25}$ turn of the spindle, or 0.001 in. To read the setting of a micrometer, simply add the reading on the barrel and the reading on the thimble. For example, to read the setting of

the micrometer shown in Fig. 13-5 note that one numbered division plus three small ones are visible on the barrel, and that the third division mark on the thimble registers at the zero line. The reading is therefore

$$0.1 + (3 \times 0.025) + 0.003 = 0.1 + 0.075 + 0.003 = 0.178 \text{ in.}$$

In using a micrometer caliper it is important that it be held properly on the part being measured. In measuring round stock, hold it

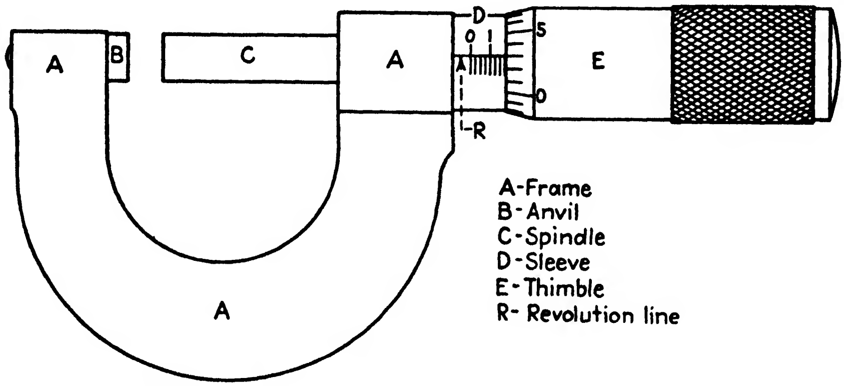


Fig. 13-5. A micrometer caliper for measuring in thousandths of an inch.

square across the stock and not at even a slight angle to it. It is also important that the screw be turned carefully but not too tight. Turning the screw too tight can easily damage the instrument as well as give a false reading.

2. TURNING BETWEEN CENTERS

One of the most common jobs on the lathe is turning between centers (see Fig. 13-6). Center holes are drilled in the ends of the stock, and it is mounted between the live center in the headstock and the stationary, or dead, center in the tailstock. The turning force is transmitted to the shaft by means of a lathe dog.

Locating and drilling centers To turn a piece between centers, the center holes in the stock must first be accurately located and drilled. There are various ways of locating the centers. Three are illustrated in Figs. 13-7, 13-8, and 13-9.

After a light center-punch mark is made in each end of the shaft, it

should be mounted between the centers on the lathe, and the accuracy of the locations of the punch marks tested as shown in Fig 13-10. Simply spin the work with one hand and mark the high points with a piece of chalk. If a punch mark is not accurately located, it may be

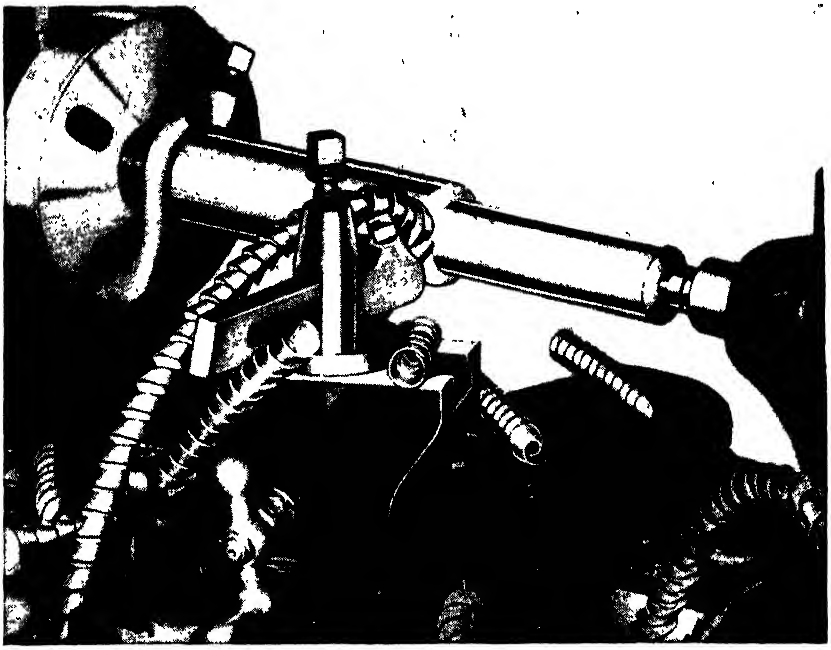


Fig. 13-6. Turning a steel shaft mounted between centers. (South Bend Lathe Works)

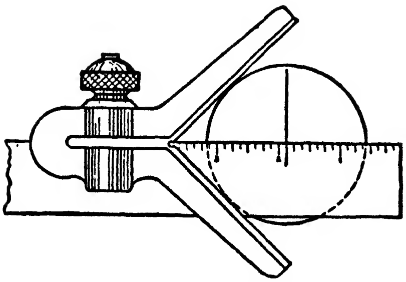


Fig. 13-7. Using a center head to locate a center. (South Bend Lathe Works)

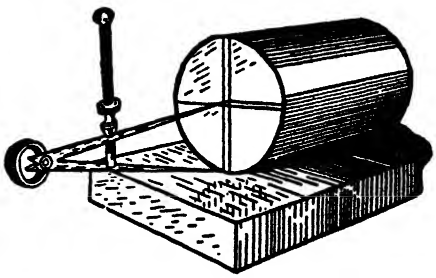


Fig. 13-8. Locating a center with dividers. (South Bend Lathe Works)

moved by driving the center punch at an angle (see Fig. 13-11). Hold the work securely in a vice while doing this.

After the punch marks are accurately located, drill the centers with a combination center drill and countersink (Fig. 13-12). A good way

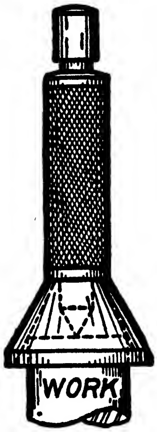


Fig. 13-9. Using a bell center punch to locate a center. (South Bend Lathe Works)

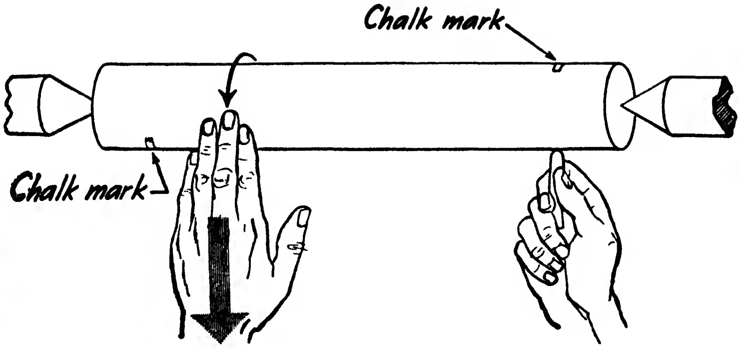


Fig. 13-10. To test the accuracy of center-punch marks, mount the shaft between centers and spin it by hand, and mark the high points with chalk. (South Bend Lathe Works)

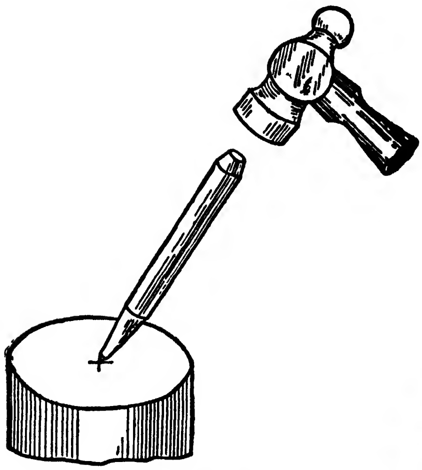


Fig. 13-11. If the center-punch mark is not accurately located, move it by driving the center punch at an angle. (South Bend Lathe Works)

Fig. 13-12. A combination drill and countersink for drilling and countersinking work to be turned between centers. (South Bend Lathe Works)

of doing this is to mount the center drill in a chuck in the headstock and feed the work against the drill as shown in Fig. 13-13. Gripping the work with the left hand keeps it from turning. Use lard oil or a cutting oil on the drill. A small-diameter shaft or rod may be center-drilled by passing it through the hollow headstock spindle and holding

it and turning it in a lathe chuck mounted on the spindle nose. The center drill is then held in a drill chuck mounted in the tailstock (see Fig. 13-14).

The center holes should be of suitable size and should be carefully

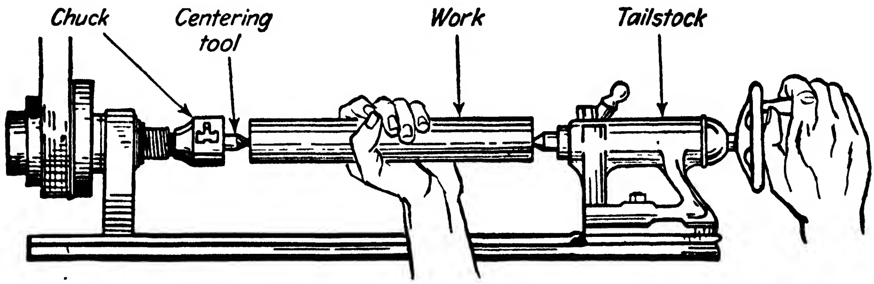


Fig. 13-13. Drilling a center hole in the end of a shaft. (South Bend Lathe Works)

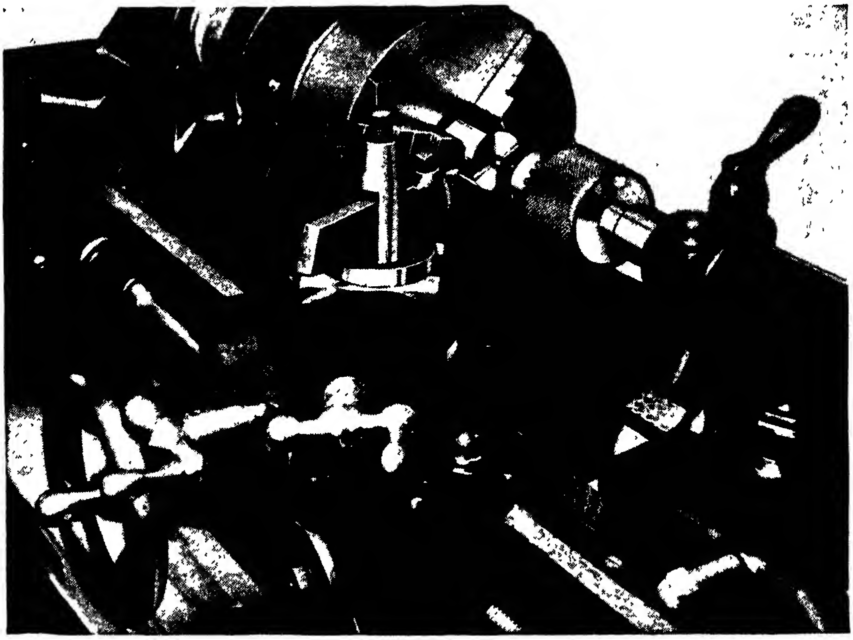
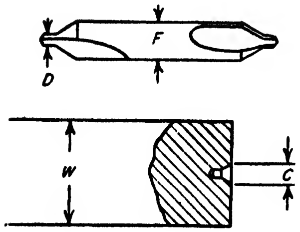


Fig. 13-14. Drilling a center hole by mounting the work in a chuck on the headstock and holding the center drill in a chuck in the tailstock. (South Bend Lathe Works)

drilled to a suitable depth. Sizes for center drill for shafts from $\frac{3}{16}$ in. to 4 in. are given in Table 13-1. If the center holes are either too shallow or too deep, they will not furnish good bearing against the lathe centers (see Figs. 13-15 and 13-16).

TABLE 13-1. Sizes of Center Holes for Shafts up to 4 In. in Diameter



Diameter of work W	Large diameter of counter-sunk hole C	Diameter of drill D	Diameter of body F
3/16 to 5/16	1/8	1/16	13/64
3/8 to 1	3/16	3/32	3/10
1 1/4 to 2	1/4	1/8	3/10
2 1/4 to 4	5/16	5/32	7/16

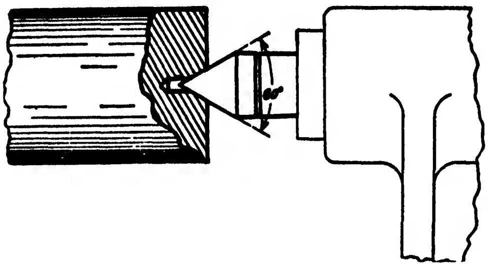


Fig. 13-15. A correctly drilled and countersunk hole fits the lathe center perfectly. (South Bend Lathe Works)

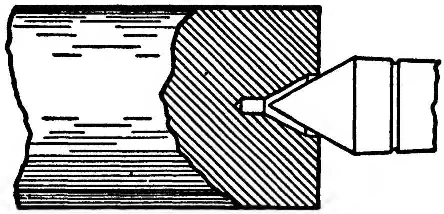


Fig. 13-16. An incorrectly drilled center hole. The hole is too deep. (South Bend Lathe Works)

Mounting and removing lathe centers Before mounting a center in either the headstock or the tailstock, be sure that both the center and the tapered hole into which it fits are clean. The tailstock center may be moved by turning the handwheel on the tailstock to the left as far as

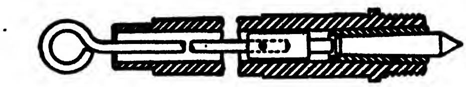


Fig. 13-17. A knockout bar for removing the center from the headstock. (South Bend Lathe Works)

it will go. The center in the headstock is removed by using a knockout bar through the headstock spindle (see Fig. 13-17).

Checking alignment of centers In order to turn a true cylinder, the lathe centers must be in alignment. The alignment may be checked by moving the tailstock up until the points of the two centers come together

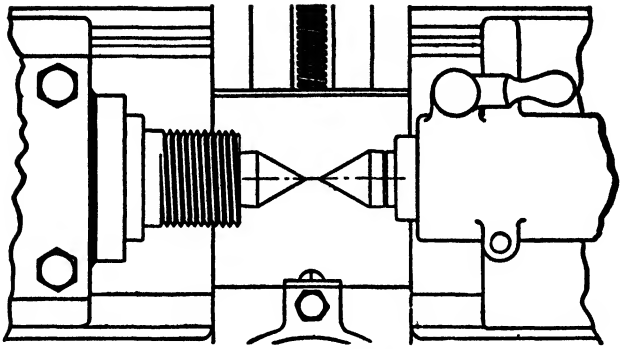


Fig. 13-18. The alignment of lathe centers may be checked by moving the tailstock up until the points of the two centers come together. (South Bend Lathe Works)

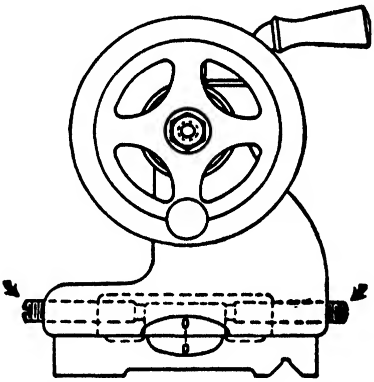


Fig. 13-19. If the lathe centers are not in alignment, move the headstock crosswise as may be required by adjusting the setover screws. (South Bend Lathe Works)

(see Fig. 13-18). If they do not align, move the tailstock by means of the tailstock setover screws as may be required (see Fig. 13-19).

Mounting the work between centers Mount a lathe dog on one end of the work and make sure the tail of the dog fits freely in a slot in the face plate mounted on the headstock. Hold the work in place between the centers, and bring the tailstock up by turning the handwheel on the tailstock. Before bringing it all the way into position, place a drop of oil in the center hole where the tailstock center will fit. Tighten the handwheel carefully. The centers must be up tight against the work, yet they must not bind. The work must turn freely. As the work is machined, it may become hot and expand; where this happens, the lathe should be stopped and the tailstock center readjusted.

Setting the tool for turning Mount the cutting tool in the toolholder and the toolholder in the tool post so as to extend over the edge

of the compound rest as little as possible (see Fig. 13-20). Excessive overhang will allow the tool to spring and cause poor work.

Also mount the toolholder in the tool post so that in case it slips it will not gouge into the work but will swing away from it (see Fig. 13-21). Whenever possible, feed the tool toward the headstock, so as to

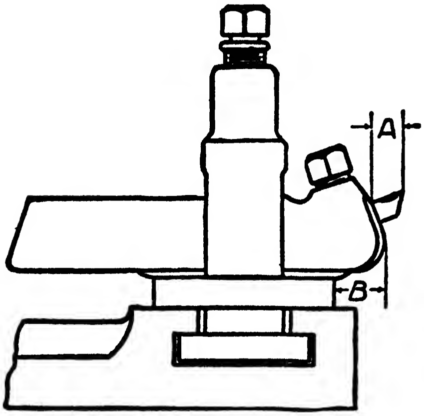


Fig. 13-20. Mount the cutting tool in the toolholder, and the holder in the tool post, so as to give a minimum of overhang. Keep dimensions A and B small. (South Bend Lathe Works)

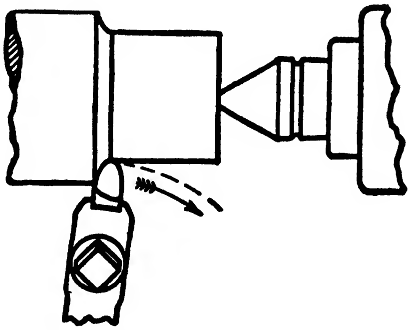


Fig. 13-21. Mount the toolholder in the tool post so that in case it slips, it will swing away from the work and not gouge. (South Bend Lathe Works)

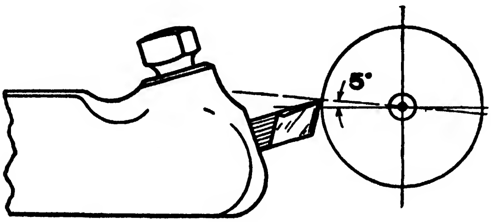


Fig. 13-22. For straight turning, set the cutter bit about 5 deg above center. (South Bend Lathe Works)

place the end pressure against the live center in the headstock, which turns with the work, instead of the tailstock center, which is stationary.

For ordinary turning, set the cutting edge of the bit a little above center, about 5 deg or $\frac{3}{64}$ in. per inch of diameter of the work (see Fig. 13-22). Be sure the tool is properly ground. See pages 425 to 428 for suggestions on grinding lathe tools. Satisfactory work with the lathe depends to a large extent upon proper sharpening and setting of the cutting tool.

Cutting speeds and feeds The best cutting speed depends upon many factors, such as the material, depth of cut, rate of feed, lubricant, if any, and the kind of cutter bit. Table 13-2 gives spindle speeds for average cutting with high-speed-steel cutter bits in different materials.

Table 13-2. Spindle Speeds in RPM for Making Average Cuts in Turning and Boring with High-speed Steel Cutter Bits

Diameter, in.	Alloy steels, 50 fpm	Castiron, 75 fpm	Machine steel, 100 fpm	Hard Brass, 150 fpm	Soft brass, 200 fpm	Aluminum, 300 fpm
1	191	287	382	573	764	1146
2	95	143	191	287	382	573
3	64	95	127	191	254	381
4	48	72	95	143	190	285
5	38	57	76	115	152	228
6	32	48	64	95	128	192
7	27	41	55	82	110	165
8	24	36	48	72	96	144
9	21	32	42	64	84	126
10	19	29	38	57	76	114
11	17	26	35	52	70	105
12	16	24	32	48	64	96
13	15	22	29	44	58	87
14	14	20	27	41	54	81
15	13	19	25	38	50	75
16	12	18	24	36	48	72

The best rate of power feed depends principally upon the size of the lathe, the depth of cut, and the nature of the work, such as whether a rough or a finish cut is being made. On a 9- or 10-in. lathe a feed of 0.008 in. per revolution of the spindle may be used, while on larger lathes, feeds up to 0.020 in. are often used in rough turning.

3. TURNING TAPERS

Turning of short tapers is easily done by setting the compound rest at the desired angle and feeding the tool by turning the compound-

rest feed screw by hand (see Fig. 13-23). To cut a taper accurately, the cutting tool must be set exactly on center.

To turn a long taper, the tailstock may be set over as shown in Fig. 13-24. Careful, accurate work is required in figuring the amount of offset and in turning tapers by this method. Taper attachments, which greatly facilitate the turning of long tapers, are available for most lathes (see Fig. 13-25).

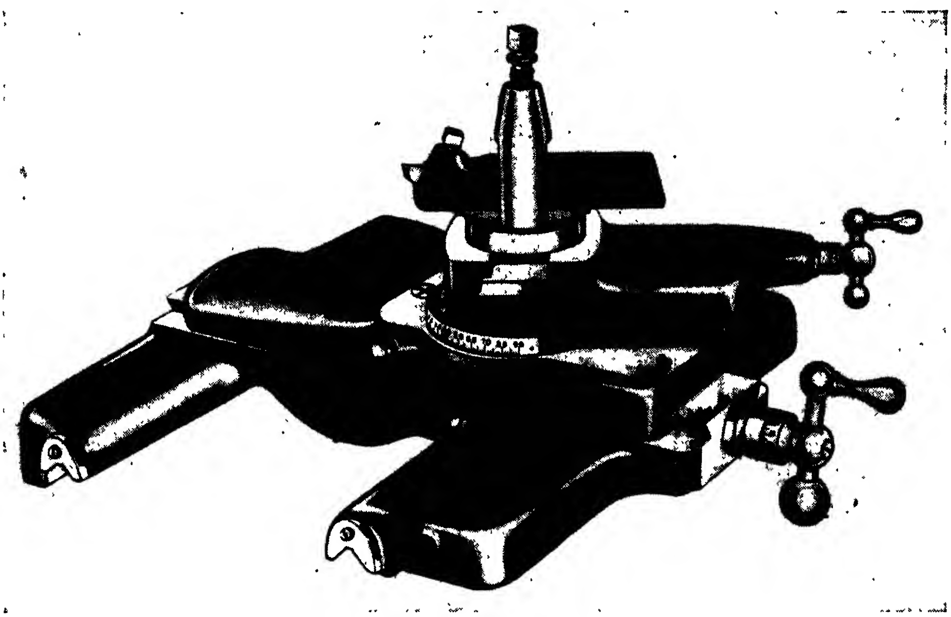


Fig. 13-23. Short tapers may be turned by setting the compound rest at the desired angle and turning the compound-rest feed screw by hand. (South Bend Lathe Works)

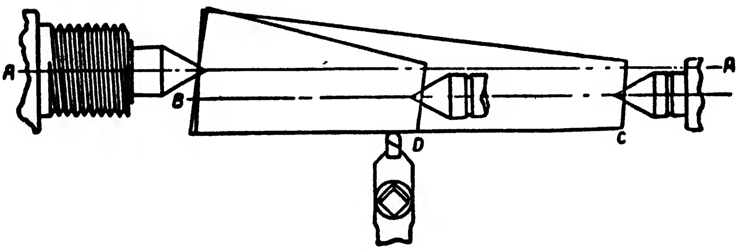


Fig. 13-24. Long tapers may be turned by offsetting the tailstock. The degree or angle of taper is determined by the amount of offset and the length of the stock. (South Bend Lathe Works)

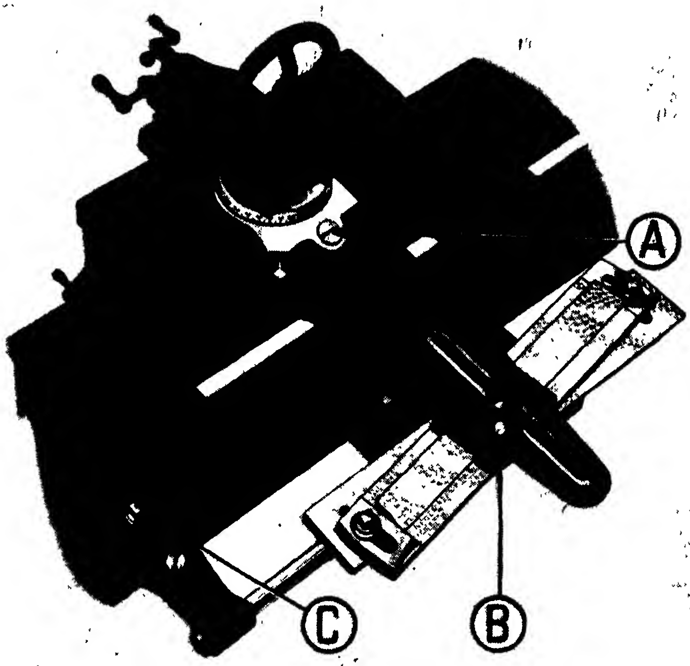


Fig. 13-25. Taper attachments are available for most lathes and are quite useful where much taper turning or boring is to be done. *A*, binding screw; *B*, connecting screw; *C*, attachment bracket screw. (South Bend Lathe Works)

4. CUTTING THREADS

Cutting of threads is accomplished on the lathe by having the cutting tool ground to give the desired shape of thread and by setting the gears which drive the lead screw so as to give the desired number of threads per inch. Either right- or left-hand threads may be cut.

To cut threads on a lathe, first determine the number of threads to be cut per inch. Then set up the lead-screw drive gears, or set the gear-change mechanism, according to the index chart on the end of the lathe. To cut United States or National Standard threads, the cutting bit is ground as shown in Fig. 13-26. It is flat on top and has an included angle of 60 deg.

Setting the cutter bit Set the compound rest at 29 deg and set the point of the tool exactly on center and square with the work, using a center gage if one is available (see Figs. 13-27 and 13-28). With the

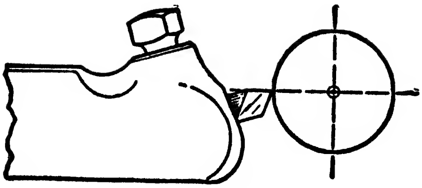


Fig. 13-26. For cutting screw threads, set the top of the cutter bit in line with the center. (South Bend Lathe Works)

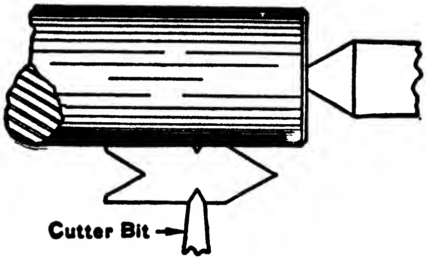


Fig. 13-27. For cutting screw threads, set the cutter bit square with the work. Use a center gage if one is available. (South Bend Lathe Works)

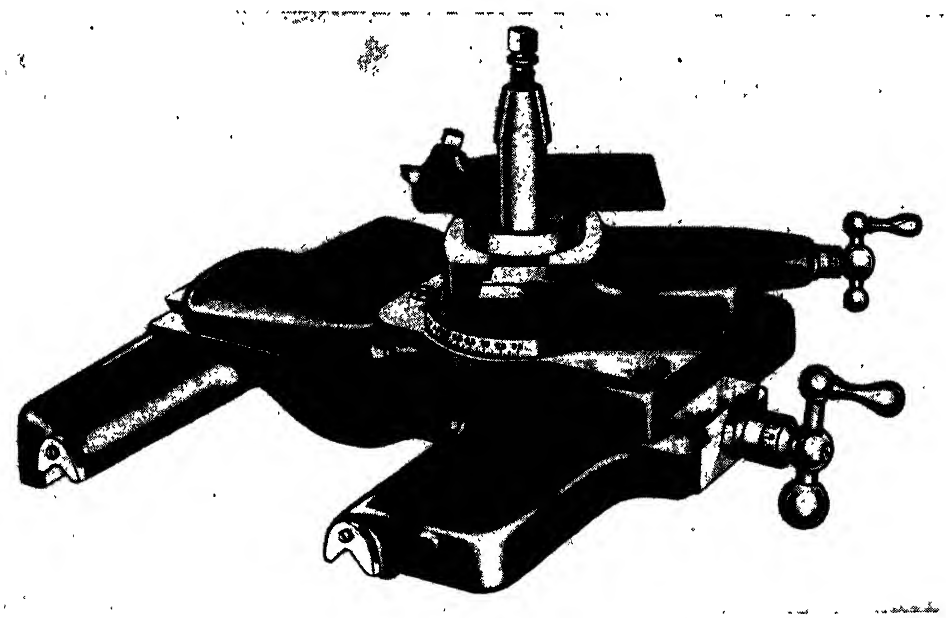


Fig. 13-28. For cutting 60-deg screw threads, set the compound rest at 29 deg and adjust the depth of cut with the compound-rest feed screw. (South Bend Lathe Works)

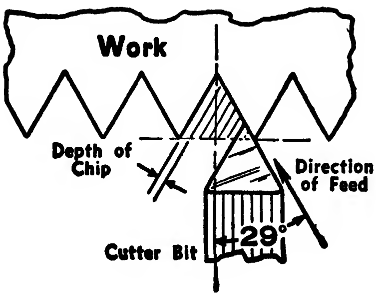


Fig. 13-29. Action of the thread-cutting tool when the compound rest is set at 29 deg. (South Bend Lathe Works)

compound rest set at 29 deg, the depth of cut may then be adjusted with the compound-rest feed screw, and the tool made to cut on one side only (see Fig. 13-29). This makes for easier and smoother cutting than with the tool cutting on both sides.

Making the first cut Set the tool up against the work and take a very light cut, just deep enough to make a light line (see Fig. 13-30). Then check the number of threads per inch, using a rule (Fig. 13-31) or a thread-pitch gage (Fig. 13-32).

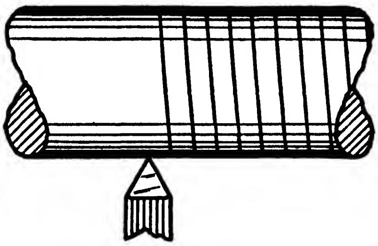


Fig. 13-30. Making a trial cut to check the setup for thread cutting. (South Bend Lathe Works)

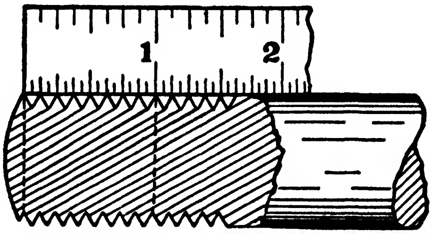


Fig. 13-31. Measuring the number of screw threads per inch with a rule. (South Bend Lathe Works)

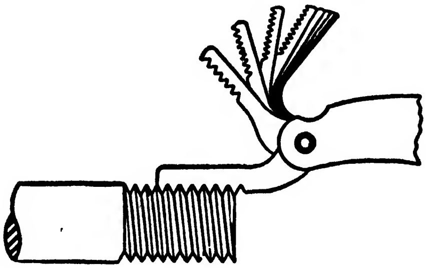


Fig. 13-32. Checking the number of threads per inch with a thread-pitch gage. (South Bend Lathe Works)

Finishing the thread At the end of the first cut, withdraw the tool by turning the cross-feed screw one complete turn to the left. Reverse the motor and return the cutting tool to the starting point without disengaging the tool carriage from the lead screw. Then turn the cross-feed screw to the right exactly one turn, and adjust the compound-rest feed screw for the desired depth of cut, usually 0.002 or 0.003 in. Take a second cut and repeat as many times as required to finish the thread. Apply lard oil or a cutting oil generously when threading steel.

It is necessary to back the cutting tool out before reversing the lathe because of the backlash in the gears which drive the lead screw. If the spindle were reversed without backing out the tool, it would bind in the

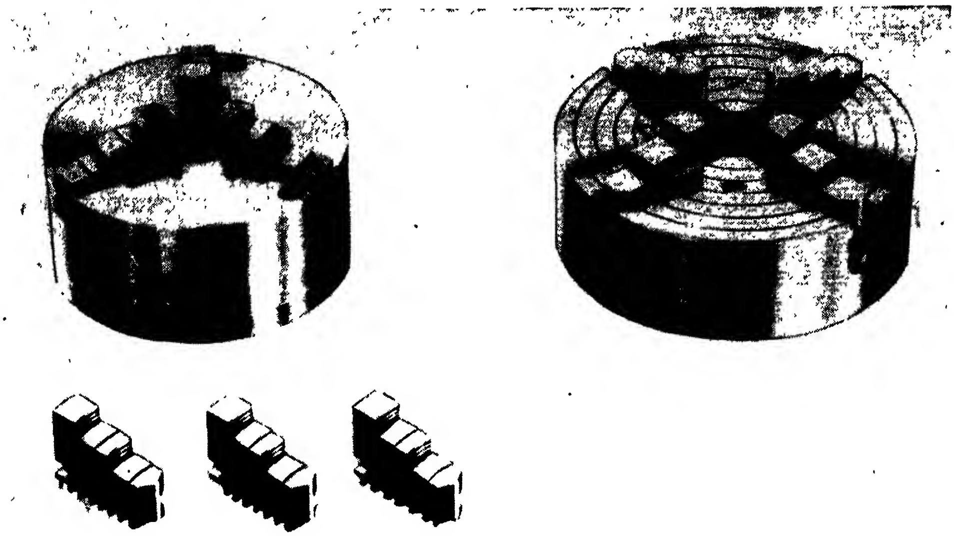


Fig. 13-33. Two types of lathe chucks, a universal 3-jaw chuck and an independent-jaw (4-jaw) chuck. (South Bend Lathe Works)

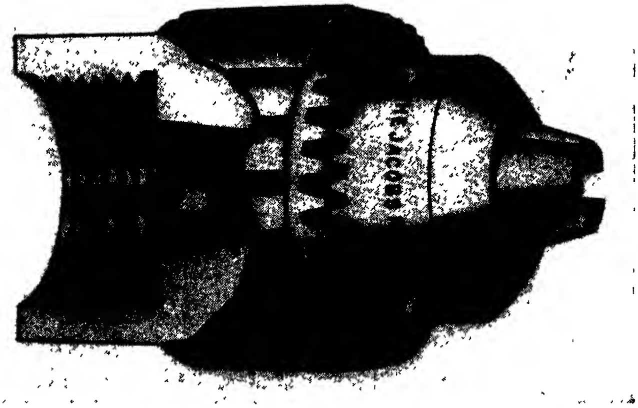


Fig. 13-34. A hollow headstock spindle chuck for holding small-diameter work. (South Bend Lathe Works)

groove and spoil the setting. Also, if a cut is not stopped soon enough, the tool may dig into the work and break the point. It is necessary, therefore, to stop the cut at exactly the right place, and to back out the tool before reversing the lathe.

To facilitate setting the tool at the right point at the beginning of each cut, the micrometer collar on the cross-feed shaft may be adjusted to zero with the point of the tool just touching the work before taking

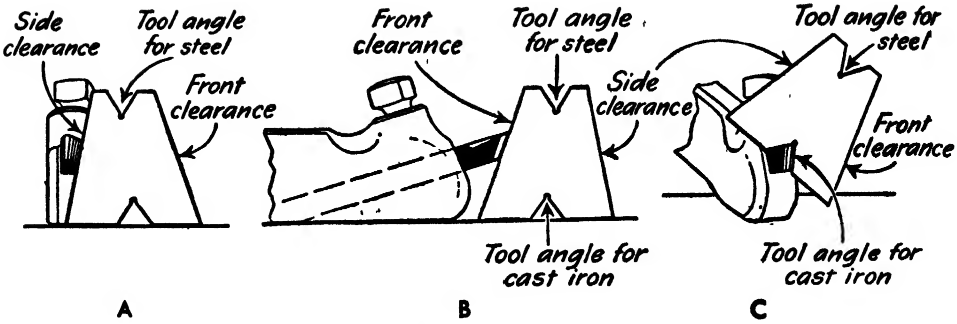


Fig. 13-35. Checking the shape of a lathe cutter bit with a bit-grinding gage: A, checking side clearance; B, checking front clearance; C, checking the tool angle. (South Bend Lathe Works)

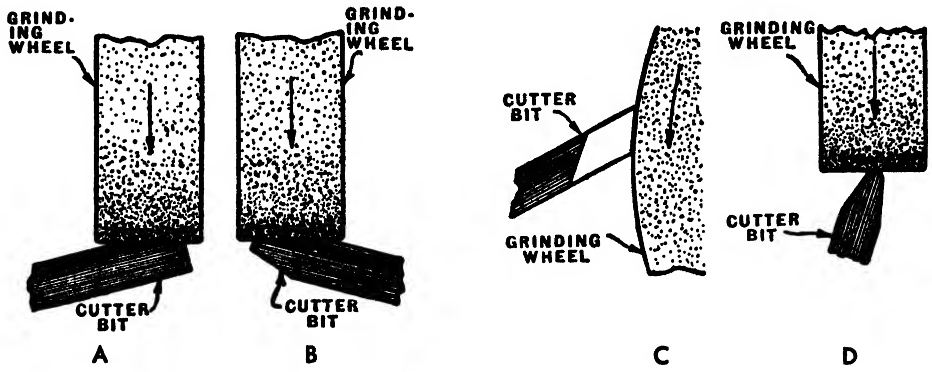
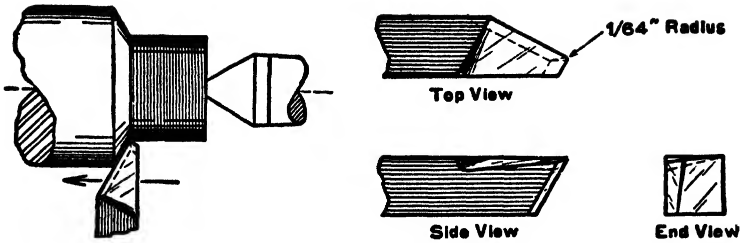


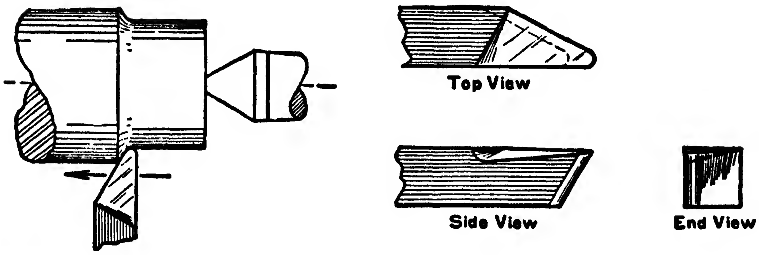
Fig. 13-36. Steps in grinding a lathe cutter bit. (South Bend Lathe Works)
A. Grinding left side of cutter bit
B. Grinding right side of cutter bit
C. Grinding front of cutter bit
D. Rounding end of cutter bit
E. Grinding side rake and back rake
F. Honing the cutting edge with an oilstone

the first cut. The cross-feed shaft is then always returned to this zero setting at the beginning of each cut, the additional depth for each new cut being set by the feed screw on the compound rest.

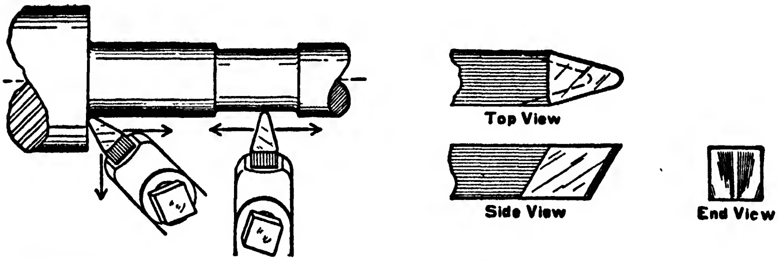
If for any reason it is necessary to remove the threading tool before the thread is finished, it must be carefully readjusted so as to follow exactly in the original groove. If much thread cutting is to be done on the lathe, two attachments, a thread stop gage and a thread dial indicator, will be found quite useful.



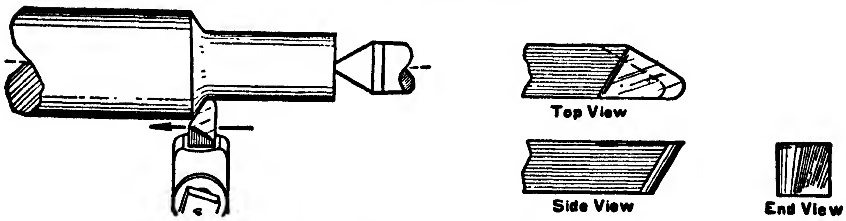
A. Roughing Tool



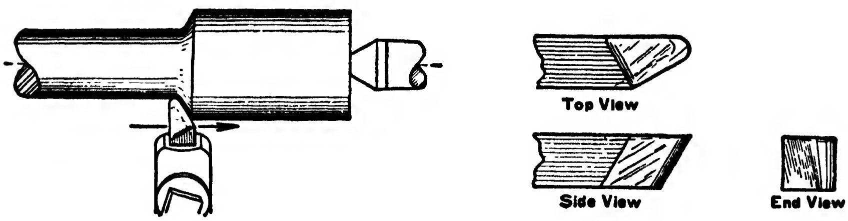
B. Finishing Tool



C. Round-nose Tool

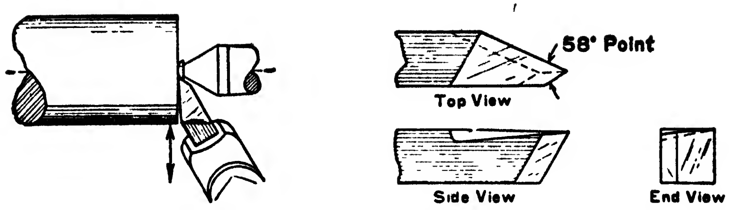


D. Right-hand Turning Tool

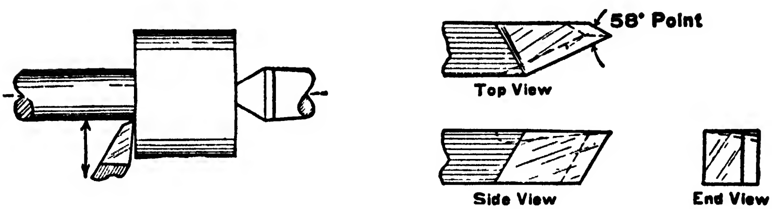


E. Left-hand Turning Tool

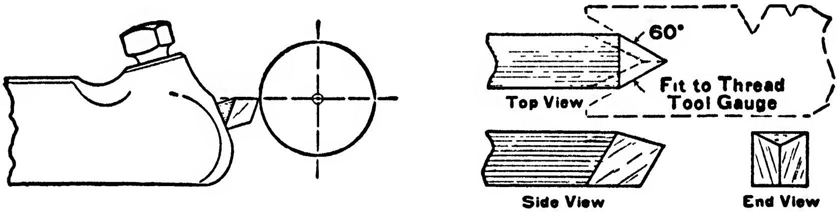
Fig. 13-37. Uses and details of grinding of var-



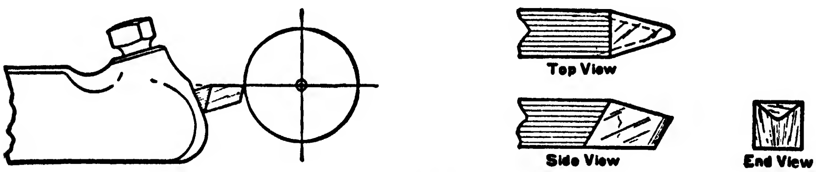
F. Right-hand Side Tool



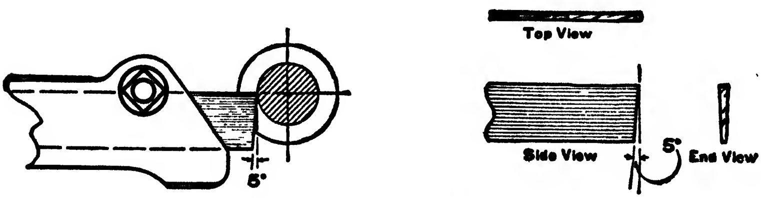
G. Left-hand Side Tool



H. Screw-thread Cutting Tool



I. Brass Turning Tool



J. Cutting-off Tool

ious lathe cutter bits. (South Bend Lathe Works)

5. CHUCKING WORK IN THE LATHE

Work that cannot be mounted between centers can often be conveniently held and turned in a chuck mounted on the headstock spindle. Three types of chucks are most commonly used, the independent-jaw (4-jaw) chuck for holding irregular work, the 3-jaw universal chuck for holding round and hexagon-shaped work (see Fig. 13-33), and the hollow headstock spindle chuck for holding small-diameter work (see Fig. 13-34). The jaws of the independent-jaw chuck are independently adjustable for accurate centering of the work. On the other two types of chucks, the jaws are geared together and automatically center the work as they are tightened.

In turning in a chuck, it is important to work as close to the chuck as possible in order to avoid springing of the piece being turned.

6. TURNING WOOD ON A METALWORKING LATHE

To turn wood on a metalworking lathe, use a special tool rest and special wood-turning spur and cup centers instead of the regular centers. These parts are available from the manufacturers of lathes and are relatively inexpensive. For best work, special pulleys should also be used on the motor and countershaft to give the higher speeds which are desirable for turning wood.

7. GRINDING CUTTER BITS FOR THE LATHE

For satisfactory results in lathe work, it is essential that the cutting tool be properly shaped. Therefore, anyone who expects to do lathe work with satisfaction or profit to himself should early master the art of sharpening his cutting bits.

The exact shape of bit to use depends upon the metal to be cut and the kind of work to be done. It is a good plan to have several bits ground for different kinds of work and to change them, rather than to regrind the bit when a different kind of work is to be done. A cutter-bit gage (Fig. 13-35) will be helpful in grinding bits to the correct angles. Honing a bit on an oilstone after grinding will not only make it cut better and smoother, but will make it stay sharp much longer. Steps in grinding a bit are illustrated in Fig. 13-36, and the shapes and uses of several of the most common cutting tools are shown in Fig. 13-37.

JOBS AND PROJECTS

1. Examine a metalworking lathe carefully and study the operator's instruction manual to make sure you understand its various parts, adjustments, and operating controls.

2. Clean and lubricate a lathe, and check over the various accessories and pieces of equipment, such as chucks, face plates, dogs, toolholders, and cutting-tool bits.

3. Drill center holes in the ends of a short piece of round shafting, mount it between centers in the lathe, and make a few practice cuts. Be sure the cutting tool is properly mounted in the toolholder and the holder is properly mounted in the tool post. Choose a suitable speed of turning and a suitable longitudinal feed for the cutting tool.

4. After taking a roughing cut, a shaft measures 0.725 in. in diameter. How much deeper will the cutting tool need to be set (how many thousandths of an inch will the knob on the cross-feed shaft need to be turned in) to give a finished diameter of 0.675 in.? Would it be 0.050 in. or 0.025 in.? Why?

5. Remove the armature from some automotive electric generator or motor, mount it in a lathe, and turn down the commutator just enough to make it smooth and true.

6. Obtain some worn spindle, axle, or shaft from some farm machine, build it up with welding equipment, and then mount it in a lathe and turn it down to size.

7. Examine some farm machines, such as corn planters, grain drills, corn pickers, combines, or pickup hay balers, and locate some straight, round shafts that may be worn and need replacing. Take careful measurements from the old parts, and turn new shafts for replacements.

14 FARM BLACKSMITHING

1. Selecting Blacksmithing Equipment for the Farm Shop
2. Building and Maintaining a Forge Fire
3. Heating Irons in a Forge
4. Cutting with the Hardy
5. Bending and Straightening Iron
6. Drawing and Upsetting Iron
7. Working Tool Steel

WHILE modern welding equipment has greatly reduced the need for blacksmithing in the farm shop, there are frequently jobs that can best be done with a forge. Where large pieces of steel are to be heated and shaped, there is no substitute for a good forge fire. A forge can often be used to advantage in preheating pieces that are to be welded with the oxyacetylene torch or the electric-arc welder. It is also useful for reshaping and tempering tools like cold chisels, punches, crowbars, and picks.

1. SELECTING BLACKSMITHING EQUIPMENT FOR THE FARM SHOP

The forge A good way to provide a forge is to build one in the shop. The hearth may be made of concrete and mounted on a stand of concrete blocks or bricks or of angle iron or pipe. A plate about 6 in. square with several holes drilled in it can be mounted in the bottom of the hearth to admit the air blast.

If a regular blower is not available, a discarded vacuum cleaner motor and blower can often be easily used. A damper or butterfly valve mounted in the pipe between the blower and the hearth can be used to control the draft.

Fig. 14-1. A forge is useful for heating and shaping large pieces of metal as well as for reshaping and tempering tools like cold chisels, punches, and picks.

The anvil Anvils are of two general kinds: cast iron and steel. Steel anvils are much better and should be used if they can be afforded. The two kinds can be readily distinguished by striking with a hammer. A cast anvil has a dead sound, while a steel one has a clear ring.

Anvils are commonly available in sizes ranging from 50 to 200 lb. An anvil weighing 100 or 125 lb is quite satisfactory for the farm shop.

A piece of railroad iron or rail 24 to 30 in. long and mounted on a block or stand (see Fig. 1-8) makes a good anvil for light hammering and riveting, although a much greater variety of work can be done on a regular anvil.

Place the anvil on a substantial mounting, preferably of wood. Locate it in front of the forge, so that the workman can take irons from the fire and place them on the anvil by simply making a short turn and without the necessity of taking even a full step. Place the horn of the

anvil to the left for a right-handed workman and to the right for a left-handed man. Mount the anvil at such a height that the top can be just touched with the knuckles of the clenched fist when standing erect and swinging the arm straight down (see Fig. 14-3).

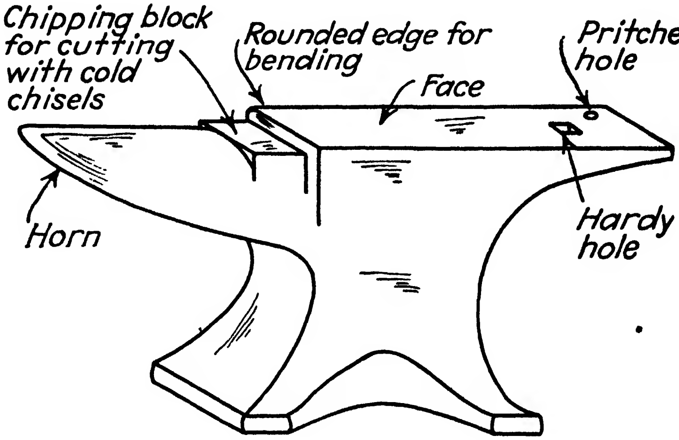


Fig. 14-2. Parts of the anvil.

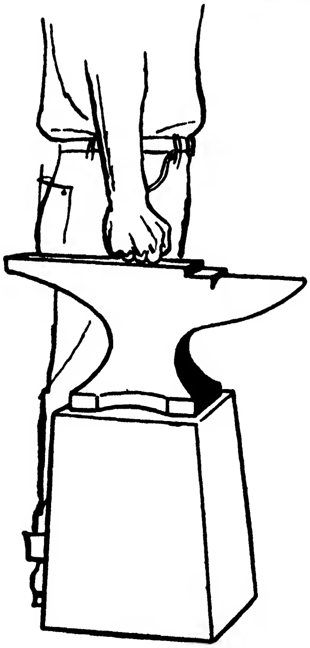


Fig. 14-3. Mount the anvil on a substantial block at such a height that it can just be reached with the knuckles of the clenched fist when standing erect.

Tongs A few pairs of tongs of different sizes and kinds should be provided for the farm shop. Various types are available, the most common ones being flat-jawed tongs and hollow-bit curved-lip tongs (see Fig. 14-4). The hollow-bit curved-lip bolt tongs are probably best for

general work. They can hold flat bars as well as round rods and bolts, and the curved part back of the tip makes it possible to reshape them easily to fit various sizes of stock. By filing or grinding a groove crosswise in the end of each lip, they can be made to hold links and rings

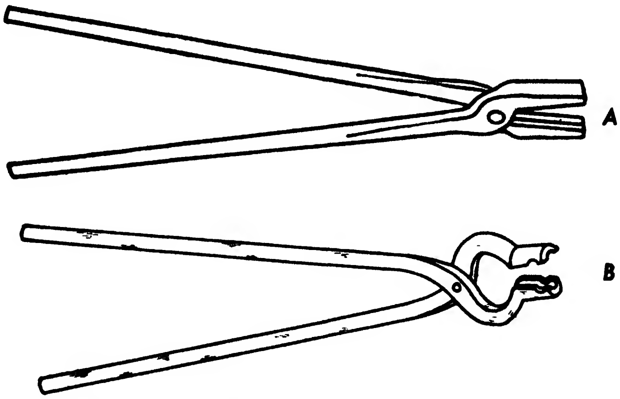


Fig. 14-4. Types of tongs: *A*, flat-jawed hollow-bit tongs; *B*, hollow-bit curved-lip tongs. This style is very good for the farm shop. Flat bars as well as round rods and bolts can be held in them.

practically as well as special link tongs. Tongs 18 to 20 in. long are a good size for average work.

Hammers A blacksmith's hand hammer weighing 1½ or 2 lb and another weighing 3 or 3½ lb will handle all ordinary work very satisfactorily.

Hardy, chisels, punches There should be at least one hardy of a size to fit the hole in the anvil, and it may be advisable to have two, one that is thin and keen for cutting hot metal, and one that is thick, heavy, and tempered for cutting cold metal. It is a good plan to have a fair assortment of various sizes of chisels and punches. These can be made easily in the shop. If considerable blacksmithing is to be done, it would be well to have a hot cutter and a cold cutter (simply large chisels with handles on them) for heavy cutting with a sledge hammer. It would be well also to have one or two large punches with handles on them for punching holes in hot metal. Punches for making holes ⅜ in. and ½ in. in diameter are probably most useful.

Vise One vise can well serve for all metalwork in the farm shop, including blacksmithing if it is heavy and strong. A blacksmith's steel

leg vise with jaws 4 to 5 in. wide is generally preferred as an all-purpose metalworking vise. A leg vise is one that has one leg extending down to be anchored or fastened into the floor (see Fig. 14-5). Such a vise can be used for heavy hammering and bending better than other types. If there is a strong steel machinist's vise in the shop, it can be

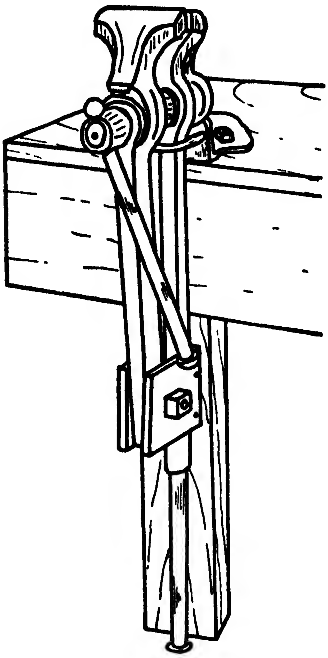


Fig. 14-5. A heavy blacksmith's steel leg vise is a good type of vise for the farm shop.

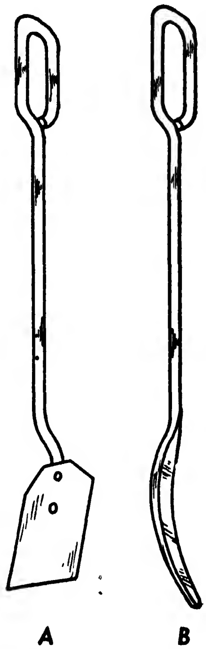


Fig. 14-6. Homemade forge fire tools: A, shovel; B, poker.

used for blacksmithing work if care is used not to do too heavy hammering or bending with it.

Fire tools A small shovel and poker or rake will be needed for use on the forge fire. These can easily be made in the shop. A flat piece of heavy sheet iron about 3 or 4 in. wide by 4 or 5 in. long, riveted to a bar or rod for a handle, makes a good shovel (see Fig. 14-6*A*). A ½-in. round rod, with an oblong eye in one end to serve as a handle and the other end flattened and curved, makes a good combination poker and rake (see Fig. 14-6*B*).

Measuring tools Some kind of metal rule will be needed for measuring and checking pieces being forged. A small steel square is very good for both measuring lengths and checking angles and bends. A caliper

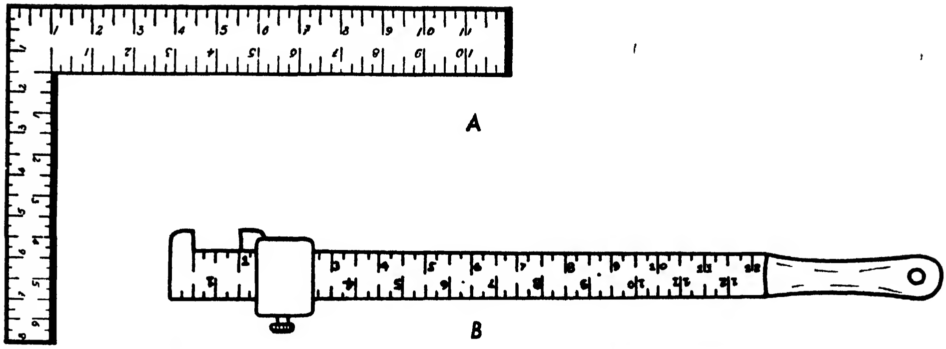


Fig. 14-7. Use metal measuring tools in blacksmithing: *A*, the small steel square is useful for checking bends and angles as well as for measuring; *B*, the caliper rule is especially good for measuring the diameter or thickness of bolts, rods, and bars, as well as for general measuring.

rule (see Fig. 14-7*B*) for measuring the diameter of rods and thickness of parts, although not a necessity, will be found convenient.

2. BUILDING AND MAINTAINING A FORGE FIRE

A good fire is the first requirement for good blacksmithing. Many beginners do poor work simply because they do not know the importance of a good fire. Two students sometimes attempt to use the same fire. This is usually a waste of time, as it is difficult or impossible to heat irons properly when someone else is poking in the fire and trying to heat other pieces at the same time.

A good fire has three characteristics. It *is clean*, that is, free from clinkers, cinders, etc. *It is deep,* with a big, deep center of live burning coke. And *it is compact*, being well banked with dampened coal.

Starting the fire To start a fire, first clean the fire bowl with the hands, pushing all coal and coke back on the hearth and *throwing out all clinkers*. Clinkers are easily distinguished from coke. They are heavy and metallic and have sharp hard corners or projections. Coke is light in weight and is easily crumbled in the hands. After removing the clinkers, shake the fine cinders and ashes through the grate into the ashpit below the tuyère (that part in the bottom of the hearth through which the blast comes). Then dump the ashpit and try the blower, making sure that a good strong blast comes through. Sometimes ashes work back into the blower pipe and obstruct the blast.

After the fire bowl is cleaned, light a handful of shavings or kindling *from the bottom* and drop them onto the tuyère. Turn the blower gently and rake fuel, preferably coke left from the previous fire, onto the burning kindling. Once the fire is burning well, rake on more coke, and pack dampened coal *on both sides and on the back* of the fire. This forms a mound of burning coke at the center. The dampened coal on the outside concentrates the heat in the center. In a little while gases will be driven off this dampened coal, sometimes called *green coal,* and it will change to coke.

If the fire tends to smoke excessively, stick the poker down through the center, opening up a hole and allowing the air to come through more freely. Most of the smoke will then usually catch fire and burn.

Always use *blacksmithing coal* in the forge. It is a high-quality soft coal that is practically free from sulfur, phosphorus, and other objectionable impurities. When dampened and packed around the fire, it readily cakes and changes to coke, which burns with a clean, intense flame. Ordinary stove or furnace coal will not work satisfactorily in a forge.

Keeping the fire in good condition When the coke at the center of the fire burns up, replace it with more coke. This may be done by mashing the fire down in the center with the shovel or rake, or by raking coke in from around the edges of the hearth, or both. Always keep the fire deep. Do not let it become hollowed out and shallow.

Add green coal to the outer parts of the center mound from time to time, as may be required to keep the fire well banked and confined to the center.

Do not continually poke at the fire; simply keep the center well supplied with coke and the outside packed down with dampened coal.

If the fire tends to spread too much, or if it becomes open and loose, throw or sprinkle water on the outer edges and pack it down with the shovel. Use only a moderate blast of air. Excessive air makes for slow heating and scaling of the irons. If a moderate speed of the blower fails to produce enough air, check for leaks in the pipe between the blower and the tuyère, or for a partial stoppage with ashes.

Cleaning the fire From time to time—usually every half hour when welding—remove the clinkers and cinders that accumulate over the tuyère. To do this, simply pass the shovel along on the bottom of the hearth to the center of the fire, and then raise it straight up

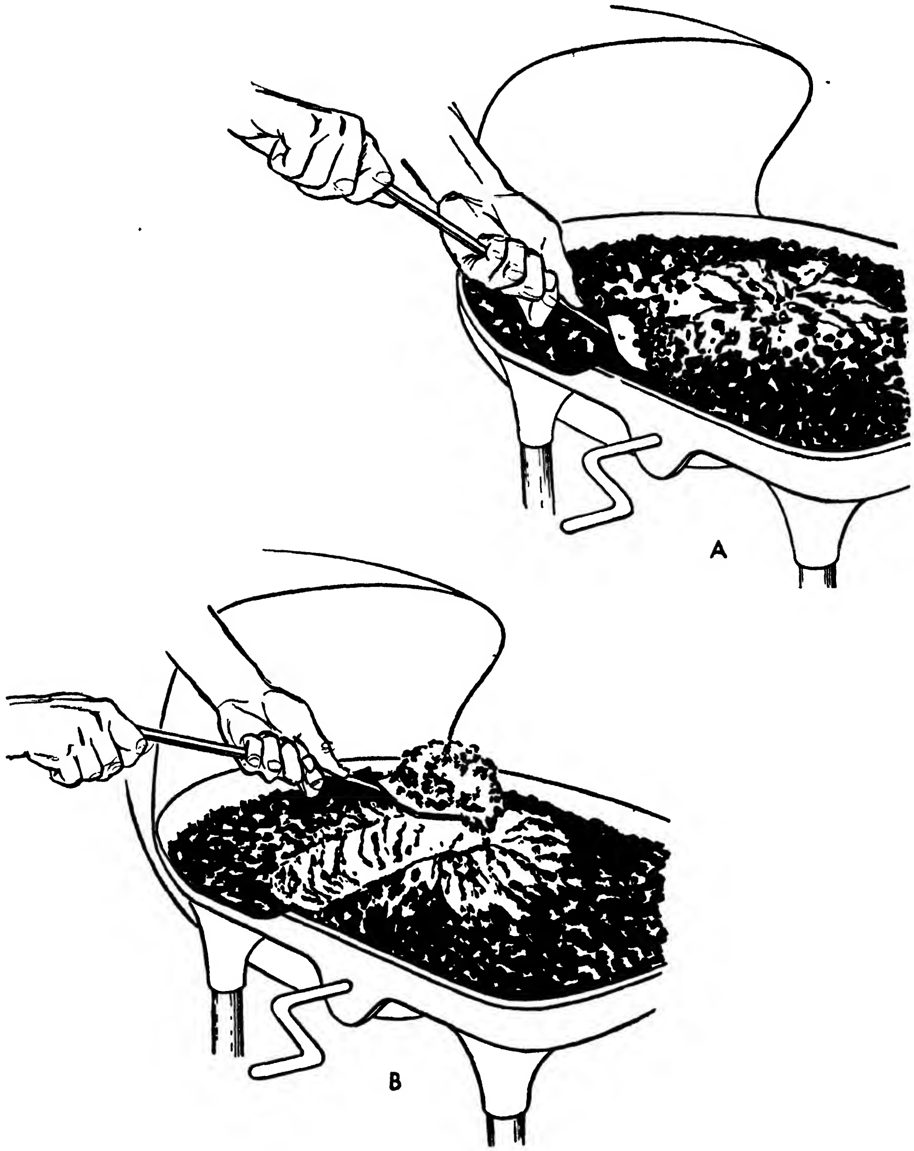


Fig. 14-8. Cleaning the forge fire. First, push the shovel along the bottom of the hearth to the center of the fire, as at *A*; and then lift straight up, as at *B*. Clinkers and ashes, if any, are then easily seen and removed.

through the fire (see Fig 14-8). The clinkers can then be easily seen and removed. Most of them will stay on the shovel.

After the cinders and clinkers are removed, rake coke back into the center and pack it down. Add fresh coal to the back and sides of the fire if needed.

Lining a forge Lining a forge hearth with clay, although generally not practiced, will protect it against overheating and rusting and will increase its useful life. A forge hearth may be lined as follows:

1. Make a thin wash of clay, preferably fire clay, and spread it over the inside of the hearth and allow it to dry.
2. Then mix fine sieved coal ash and clay together, using 1 part of coal ash to 3 parts of clay. Add enough water to make the mixture about as stiff as putty, and apply it about one inch thick around the tuyère opening and at least 8 in. on the sides.
3. Allow it to dry overnight.
4. Then build a wood fire and bake slowly for at least an hour, turning the blower a little every 10 or 15 min. to keep the fire going.

In using the forge, be careful not to break up the clay lining with the poker or shovel.

3. HEATING IRONS IN A FORGE

To heat irons in a forge fire, place them in the fire in a *horizontal position,* not pointing down (see Fig. 14-9). Be sure there is burning coke *below the irons, on both sides of them, and on top of them.* Keep the fire deep and compact. Irons heat much more rapidly and oxidize

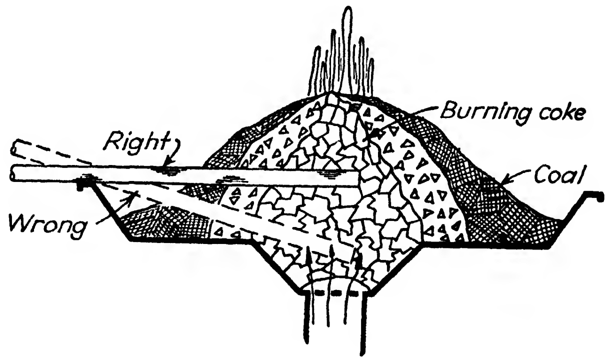


Fig. 14-9. In heating irons in the forge, keep them pointed straight in—not down. Keep burning coke below them, on all sides of them, and on top of them.

or scale off much less when heated in a deep compact fire than in a shallow, burned-out fire. Some scale will form in spite of a good fire, but the scale should be kept to a minimum.

Small thin parts heat much more rapidly than heavier and thicker parts. To avoid burning the thinner parts, push them on through the

fire to a cooler place, or else change the position of the irons to make all parts heat uniformly.

For forging mild steel or blacksmith iron, heat it to a good bright-red heat. Do not allow it to get white hot and sparkle. Sparkling indicates burning. Tool steel must not be heated as hot as mild steel. A bright-red or low-orange heat is hot enough for tool steel.

Fitting tongs; holding the work If tongs cannot be found to fit the work, reshape a pair by heating and hammering the jaws over the piece to be held. Poorly fitting tongs are a source of continual trouble and should not be used.

A considerable amount of work can be done without the use of tongs. An eyebolt, for example, can be made on the end of a rod 20 to 30 in. long and then can be cut off when finished.

4. CUTTING WITH THE HARDY

A blacksmith does much of his cutting of iron and steel on the hardy. Although the hardy does not leave quite as smooth a cut as a hack saw, it is quite satisfactory for most blacksmith work. It cuts

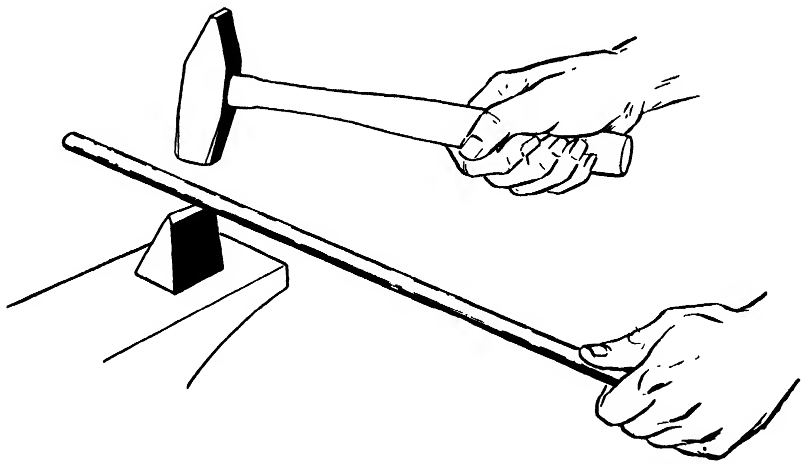


Fig. 14-10. Cutting an iron rod on the hardy. To cut cold iron, nick deeply on two or more sides and then break by bending. In cutting hot iron, cut all the way through from one side, being careful to strike overhanging blows at the last to prevent striking the cutting edge with the hammer.

faster and more easily than a saw and is less expensive, as there are no blades to wear out or break.

To use a hardy, place it in the hardy hole (the square hole) in the anvil, lay the bar or rod on it at the point to be cut, and hammer

it down against the sharp edge (see Fig. 14-10). Hardies may be used for either hot or cold cutting. Some smiths prefer to keep two hardies, one that is thick and stocky and tempered, for cutting cold iron, and one that is thin, for cutting hot iron. The hardy, like other cutting tools, works better if kept sharp. It may be ground like a cold chisel.

In cutting cold iron, the bar may be nicked deeply on two or more sides and then broken off by bending. In cutting hot iron, it is common practice to cut clear through from one side. Care must be taken, of course, not to let the hammer strike the cutting edge of the hardy, or else both the hammer and the hardy may be damaged. In finishing a cut on a hardy, strike the last two or three blows just beyond the cutting edge and not directly over it.

Cutting tool steel Never attempt to cut tool steel in the hardened state. To cut it on the hardy, cut it hot—not cold—and handle it just like other iron or steel (except, of course, that it must not be heated above a cherry-red or low-orange heat).

When it is important to have a smooth cut, it is better to cut tool steel by sawing part way through with a hack saw, clamping it in a heavy vise at the sawing line, and then breaking it by hammering (see page 377).

Estimating amount of stock required Often before cutting off a piece of stock, it is necessary to estimate the amount required for bends and curves. To determine the amount required for a piece of irregular shape, a small wire may be bent into the desired shape and then straightened out and measured. To estimate the length of stock required for pieces of regular shape, like circles and parts of circles, estimate the length of the center line. For example, suppose it is desired to estimate the length of stock required for a ring 3½ in. inside diameter, the stock itself to be ½ in. thick. The length needed will be the length of the mid-line, halfway between the inside and outside edges. This length will be equal to the mid-diameter, 4 in., times 3.1416, or approximately 12½ in.

5. BENDING AND STRAIGHTENING IRON

In bending iron at the anvil, two points are most important:

1. Heat the iron to a good bright-red heat, almost but not quite white hot, throughout the section to be bent.
2. Use bending or leverage blows—not mashing blows.

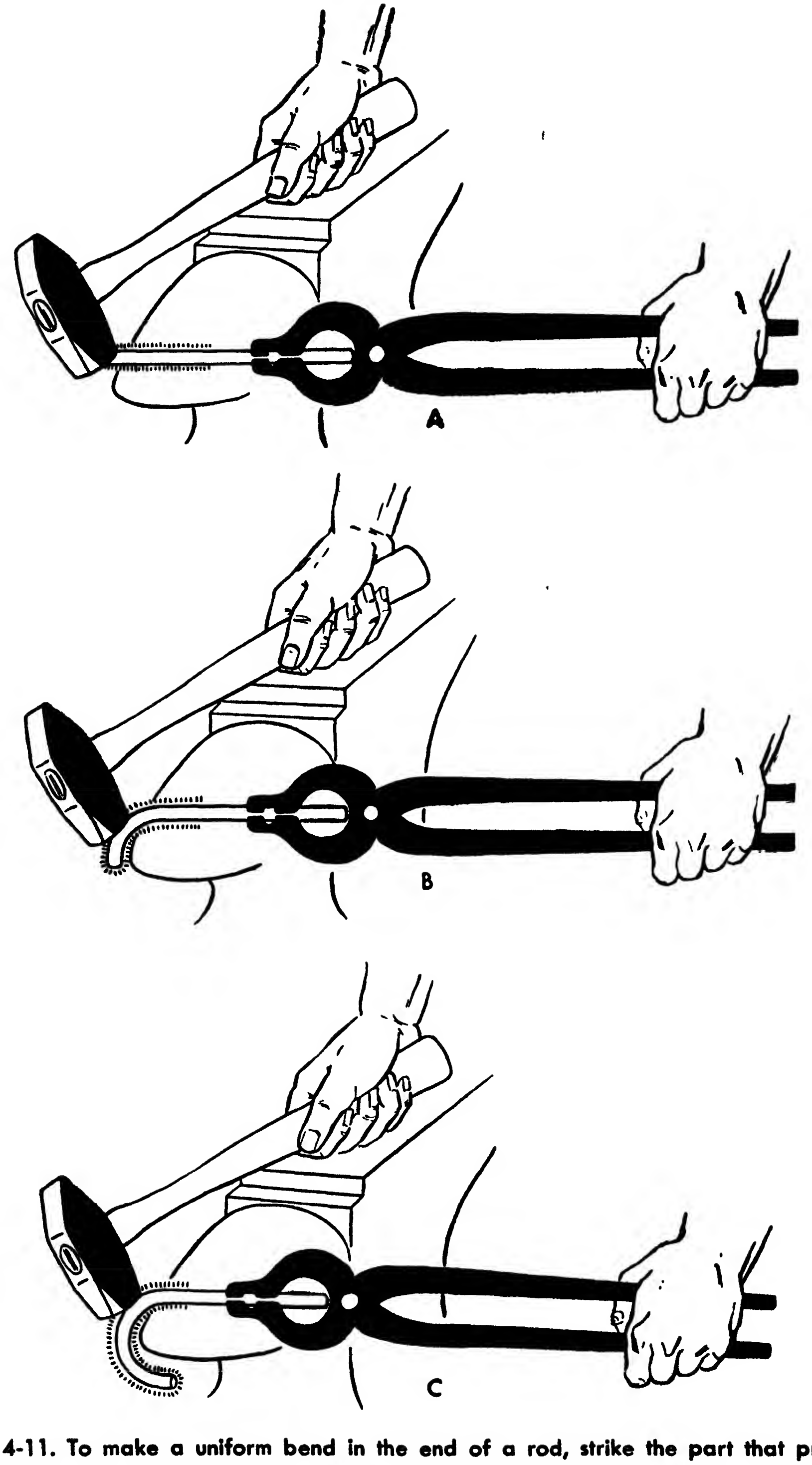


Fig. 14-11. To make a uniform bend in the end of a rod, strike the part that projects beyond the horn and keep feeding the rod forward with the tongs as the bending progresses. Keep the iron at a good working heat, and do not strike the rod where it rests on the horn.

Place the iron on the anvil so that it can bend under the hammer blows without being forced down against the anvil and mashed (see Fig. 14-11). If an iron is struck at a point where it is resting firmly against the anvil, it will be mashed instead of bent. A few moderately sharp blows are better than several lighter blows.

Making square bends Make abrupt square bends over the face of the anvil near the chipping block where the corner of the anvil is rounded to prevent marring or galling the iron (see Fig. 14-12).

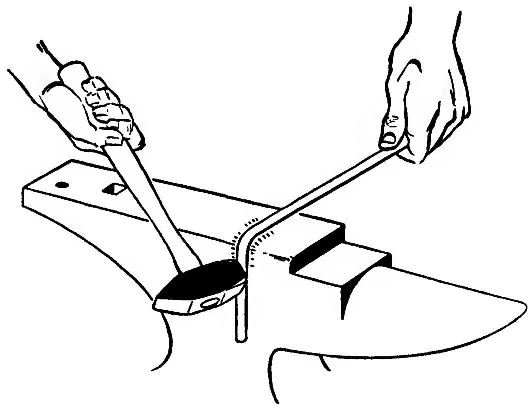


Fig. 14-12. Make abrupt square bends over the face of the anvil near the chipping block. Here, the corner of the anvil is rounded to prevent galling the iron.

As soon as the iron falls below a good bending heat, put it back in the fire and reheat it. To bend an iron at a certain point without bending the adjacent section, heat it to a high red heat, and quickly cool it up to the place of bending by dipping into water. Then bend quickly by hammering or other suitable methods.

Bending flat bars edgeways A flat bar can usually be bent edgeways by heating and placing over the horn and bending the two ends down slowly, using the hands if the piece is long enough, or two pairs of tongs in case of short pieces (see Fig. 14-13). Sometimes the bending can be done easily by simply putting one end of the piece in the hardy hole and pulling on the other end (see Fig. 14-14). If the iron starts to buckle, stop bending at once and lay it on the anvil and straighten it. Hammering the outside edge of the iron when it is laid flat will tend to stretch it and therefore help with the bending. Once the bend is well

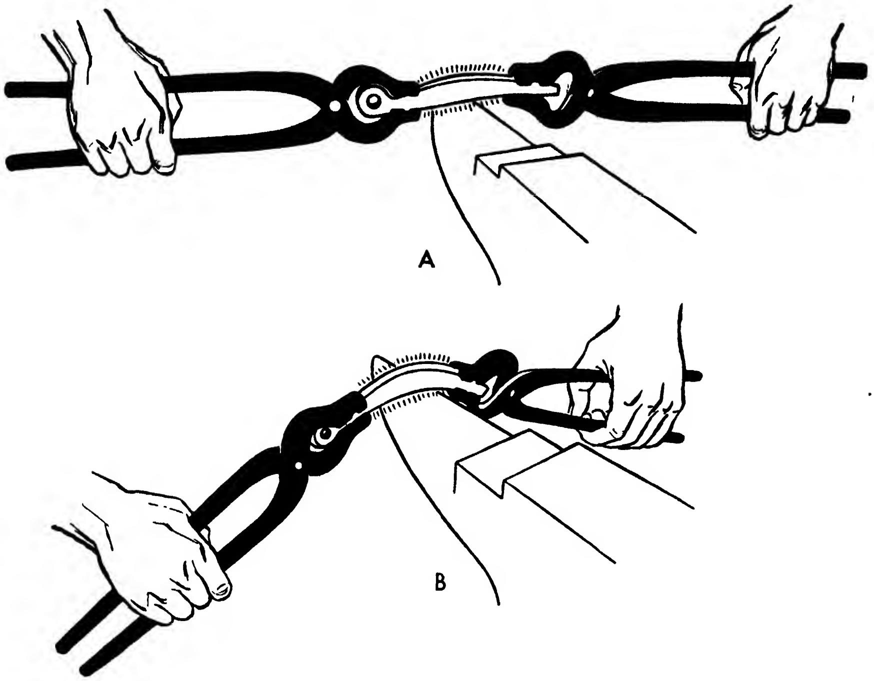


Fig. 14-13. Flat iron may be bent edgeways by heating to nearly a white heat and bending slowly with tongs. This method is good in making flat chain hooks.

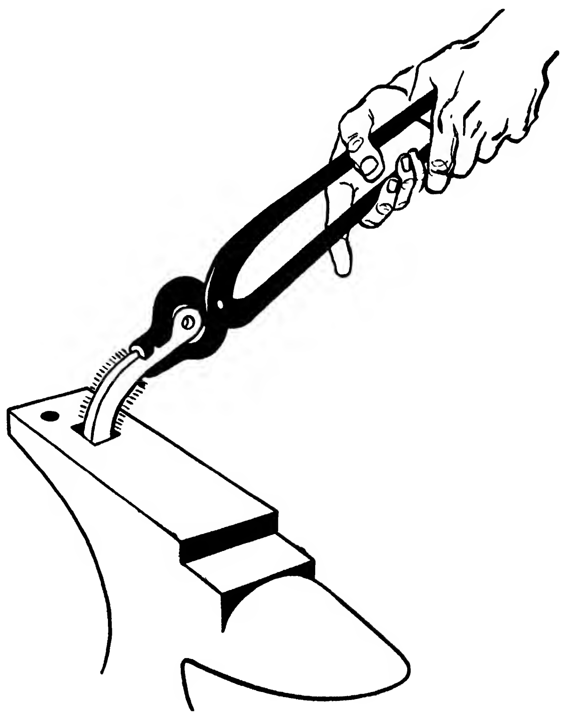


Fig. 14-14. Bending of heavy pieces can sometimes be best accomplished in the hardy hole.

started, hammering on edge around the horn is not so difficult. Be sure to always hold the stock firmly, either with the hands or with tongs, and to keep the part to be bent at a high red heat.

Straightening Straightening can usually best be done on the face of the anvil. Be sure to hold the stock firmly, and to strike at points where it does not touch the anvil face. Sighting along the stock is the best way to test for straightness and to locate high points that need striking.

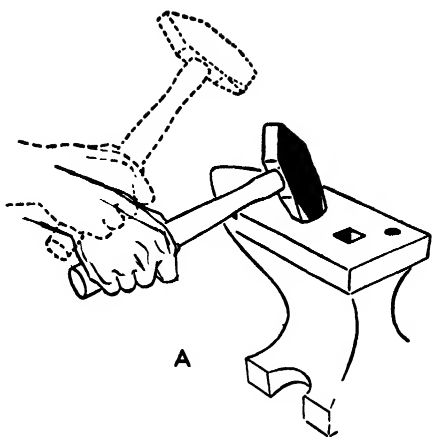
Striking with the hammer Success in blacksmithing depends largely upon the ability to strike effectively with the hammer. Most blacksmithing requires heavy, well-directed blows. Where light blows are better, however, they should be used.

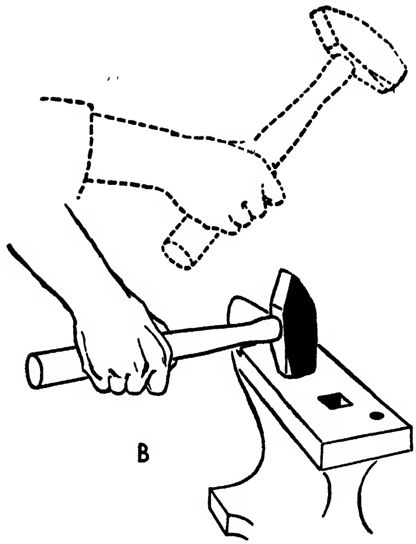
Strike light blows mostly with motion from the wrist (see Fig. 14-15*A*). Use both wrist and elbow action for medium blows (see Fig. 14-15*B*). For heavy blows, use shoulder action as well as elbow and wrist motion (see Fig. 14-15*C*).

To direct hammer blows accurately, strike one or two light taps first, to get the proper direction and feel of the hammer, and then follow with quick sharp blows of appropriate force or strength. It is also important to use a hammer of appropriate size. A heavy hammer on light work is awkward, and blows cannot be accurately placed. And using a light hammer on heavy work is very slow and tedious.

Bending and forming an eye One of the most common bending jobs in the blacksmith shop is that of forming an eye on the end of a rod. The following is a good method of making such an eye:

1. Heat the rod to a good red heat back for a distance of about 5 to 8 in., depending on the size of the eye.
2. Quickly place the rod across the face of the anvil with just enough of the heated end projecting beyond the edge of the anvil to form the eye. For exact work, the length of hot iron that is to project over may be quickly measured with a metal rule (see Fig. 14-16*A* and *B*). Place the iron across the anvil well up near the horn where the edge is rounded.
3. Bend the end down, forming a square bend, with a few well-directed blows (see Fig. 14-16*C*). Work rapidly before the iron cools. In





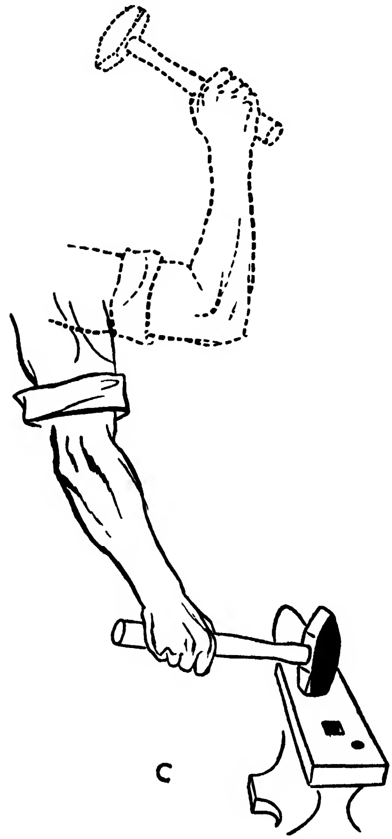
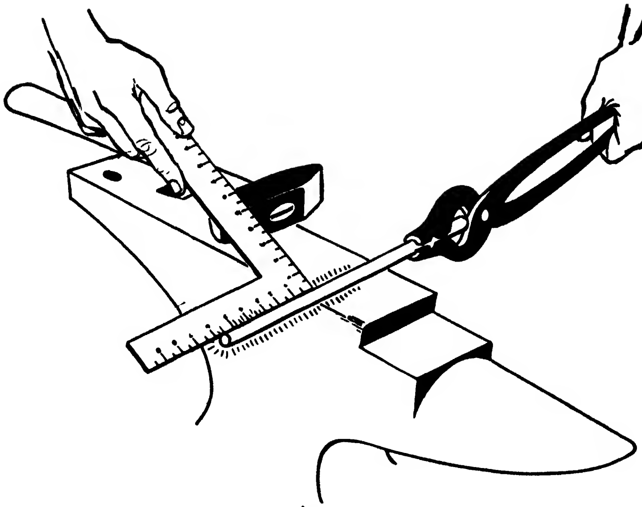
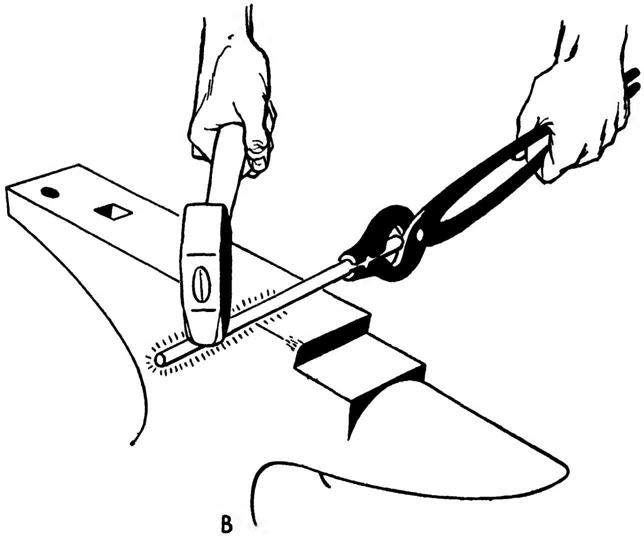


Fig. 14-15. Striking with the hammer. Strike light blows largely with wrist motion, as at *A*; moderate blows with elbow and wrist motion, as at *B*; and heavy blows with shoulder action, as well as with wrist and elbow motion, as at C.



A



B

Fig. 14-16. Steps in making an eye:

A. Place a well-heated iron across the anvil with enough stock projecting over to form the eye. Where the eye must be made accurately to size, use a metal rule or square for measuring. Work rapidly.

B. Bending the projecting portion down, forming a right angle.

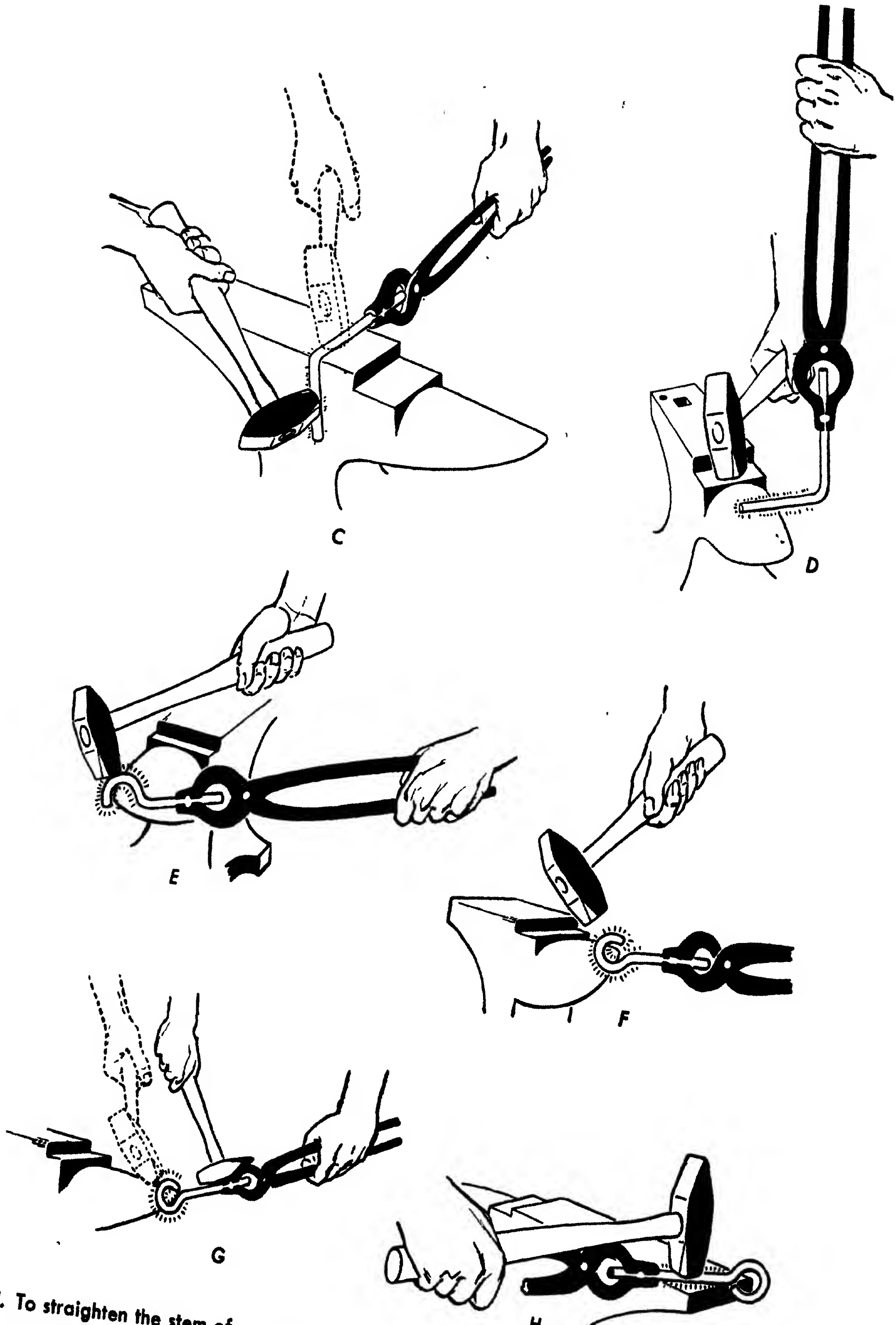
C. Finish the right-angle bend by striking alternately on top and on the side, keeping the iron at a good working heat all the while.

D. Start bending the tip end around the horn, being careful to strike "overhanging" or bending blows.

E. Gradually work back from the end to the square bend.

F. Turn the eye over and close it up. Exert considerable back pull on the tongs to keep the upper part of the eye up off the horn. In this position the hammer can strike bending blows instead of flattening or mashing blows.

G. Round the eye by driving it back over the point of the horn. Carefully note where the eye does not touch the horn and strike down lightly in these places.



H. To straighten the stem of an eyebolt, place it across the corner of the anvil face and strike the high points while the iron is at a good working heat.

finishing the bend, strike alternately on the top of the anvil and then on the front vertical side.

4. Heat the end of the stock, and start bending the tip end around the horn. Work from the tip back toward the stem (see Fig. 14-16*D*, *E*, and *F*). Keep the iron hot throughout the part being bent; otherwise the bending will be slow and difficult, and the iron will not bend at just the places desired. If the square bend at the juncture of the stem and eye tends to straighten out, it is an indication that the end of the stock is not being kept hot enough while being bent.
5. Round the eye by driving it back over the point of the horn, noting carefully where it does not rest against the horn and striking down lightly in these places (see Fig. 14-16*G*). Keep the iron well heated.
6. Center the eye on the stem, if necessary, by placing the stem flat on the anvil face with the eye projecting over the edge, and strike the eye. Have the stock well heated at the juncture of the stem and eye, but have the eye itself practically cold. Such a condition can be produced by heating the whole eye and then quickly cooling most of the rounded part by dipping in water.

Blacking After forging a piece of iron, it is a good plan to black it by heating it slightly and rubbing it with an oily rag (see Fig. 14-17).

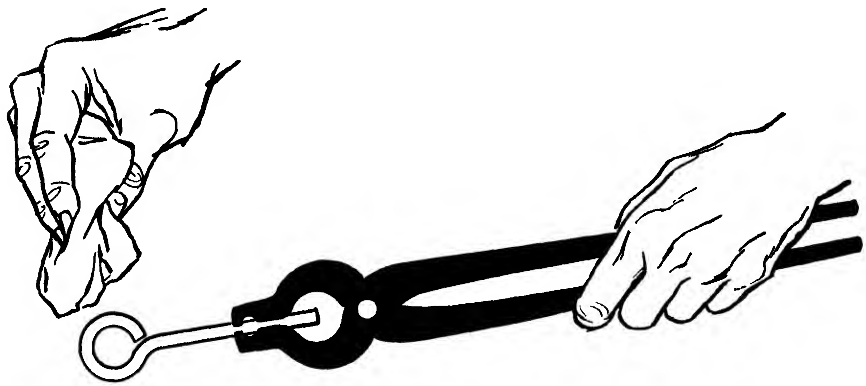


Fig. 14-17. An iron may be blacked by heating it slightly and rubbing it with an oily rag. Have the iron just hot enough to make the rag smoke. Blacking improves the appearance and affords some protection against rust.

Blacking gives the piece a better appearance and provides some protection against rusting. In blacking an iron, heat it just hot enough to burn off the oil that is rubbed on. It should not be red hot. If the iron is not hot enough, it will have a greasy appearance after rubbing with an oily rag.

Do not black tempered tools in this manner, as heating would draw the temper.

Twisting Twisting is really a form of bending. Small pieces may be twisted by heating, clamping a pair of tongs on each end of the section to be twisted, and applying a turning or twisting force. To twist larger pieces (say more than about ¼ in. thick by 1 in. wide), clamp them in a vise and twist with a pair of tongs or a monkey wrench

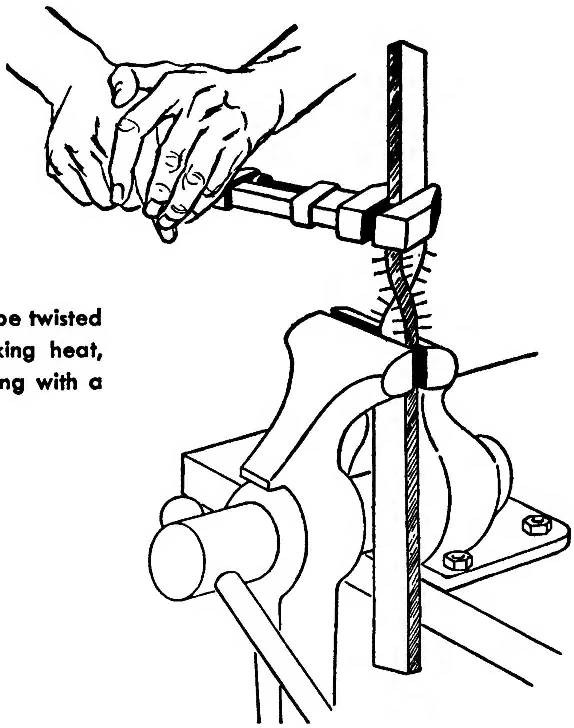


Fig. 14-18. Heavy bars may be twisted by heating to a good working heat, clamping in a vise, and twisting with a wrench or a pair of tongs.

(see Fig. 14-18). Be careful to clamp the vise and the tongs or wrench at exactly the ends of the section to be twisted.

In twisting, work rapidly before the iron cools. For a uniform twist, the iron must be at a uniform temperature. If the twist is to be confined to a definite section of the stock, it is a good plan to place center-punch marks at the ends of the section before it is heated.

6. DRAWING AND UPSETTING IRON

Drawing is the process of making a piece longer and thinner. Two points are particularly important in drawing:

1. Keep the iron at a good forging heat, a high-red or nearly white heat.
2. Use *heavy, straight-down, square* blows.

Many beginners make the mistake of striking a combination down-and-forward pushing blow, thinking that the pushing helps to stretch the metal.

Drawing may be done more rapidly over the horn than on the face of the anvil, as the round horn wedges up into the metal and lengthens it and there is less tendency for it to stretch in all directions. If a piece tends to get too wide, place it on edge and hammer it.

Keep the iron hot. Hammering after the red heat leaves is hard work and accomplishes little. Also, the iron is apt to split or crack if hammered too cold.

Drawing round rods To make a round rod smaller, the following steps should be carefully followed:

1. Make it four-sided, or square in cross section.
2. Draw it to approximately the desired size *while it is square.*
3. Make it *distinctly eight-sided* by hammering on the corners *after it is drawn* sufficiently.
4. Make it round again by rolling it *slowly* on the anvil and hammering *rapidly* with *light* blows or taps.

An attempt to draw round rods without first going to the square section not only requires a lot of extra work, but usually results in a badly distorted and misshapen piece.

Pointing a rod To make a round point on a rod, first make a *square* tapered point. Then make it eight-sided, and finally round. In pointing a rod, the following suggestions are important.

1. Work on the *far edge* of the anvil. The toe of the hammer is then not likely to strike the face of the anvil.
2. Raise the back end of the rod.
3. Strike with the toe of the hammer lower than the heel (see Fig. 14-19).

After the point is drawn, sight to see if it is centered, or roll the rod on a flat surface and see if the point wobbles up and down (see

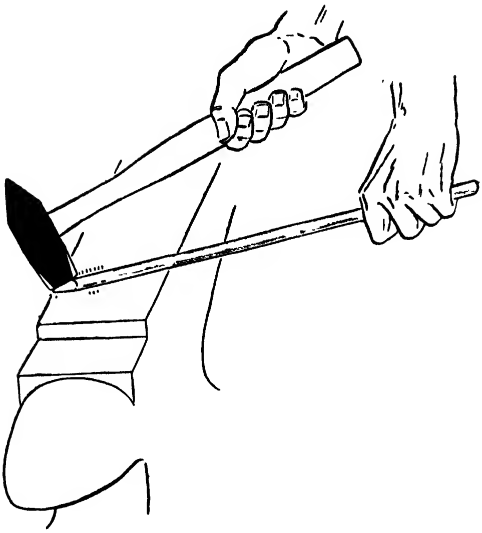


Fig. 14-19. In pointing the end of a rod, three things are important: (1) raise the back end; (2) tilt the toe of the hammer down; (3) work on the far edge of the anvil. To make a round point, make it square first, then eight-sided, and finally round.

Fig. 14-20. To tell whether a punch or rod is straight and the point centered, roll it on a flat surface. If the point wobbles, it is off center.

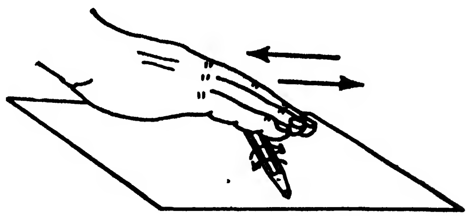


Fig. 14-20). A few well-placed blows of the hammer are usually all that is required to center the point.

Upsetting Upsetting is simply the reverse of drawing, or the process of making a piece shorter and thicker. It is done when more metal is needed to give extra strength, as when a hole is to be punched for an eye. There are two main points to be observed in upsetting:

1. Heat the bar or rod to a high-red or nearly white heat throughout the section to be upset.
2. Strike *extremely heavy* well-directed blows.
3. If the bar bends, stop and straighten it.

Light blows simply flatten and burr the end instead of upsetting the piece throughout the heated section. The extra-heavy blows needed

for upsetting can best be struck by first striking a light blow or two to get the direction of striking and then following with an extra-heavy blow. If the bar starts to bend, stop and straighten it at once. Further hammering will simply bend it more instead of upsetting it.

Probably the best way to upset a short piece is to place the hot end down on the anvil and strike the cold end (see Fig. 14-21). The hot end, of course, may be up, but it is usually easier to upset without bending if the hot end is down.

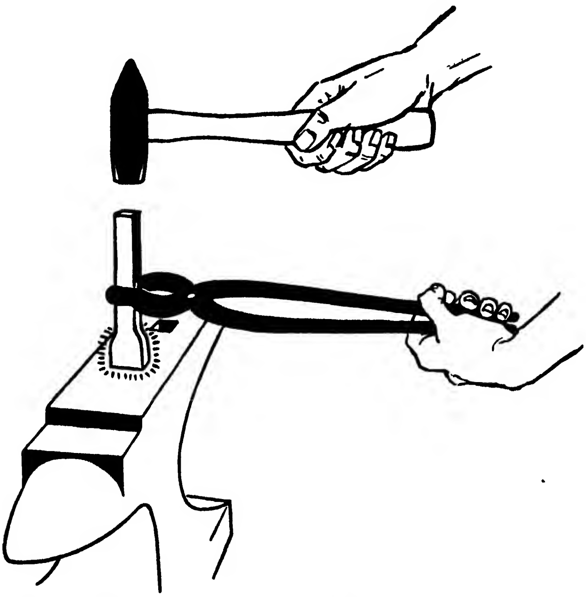


Fig. 14-21. To ensure success in upsetting, work the iron just under a white heat and strike tremendously heavy blows. Light blows simply flare the end without upsetting very far back from the end.

Usually three heats are enough for upsetting a piece. When more than three heats are required, it is generally an indication that the iron has not been heated enough or that the hammer blows have been too light.

In order to thoroughly heat the part to be upset, and yet confine the heat to this part, heat the work somewhat further than the upsetting is to go and then cool it quickly back to the line of upsetting by dipping in water (see Fig. 14-22).

The end of a long bar may be upset by laying it on the anvil face, with the hot end projecting beyond the edge, and striking heavy blows endways with a hammer. If the bar is long and heavy enough, it may

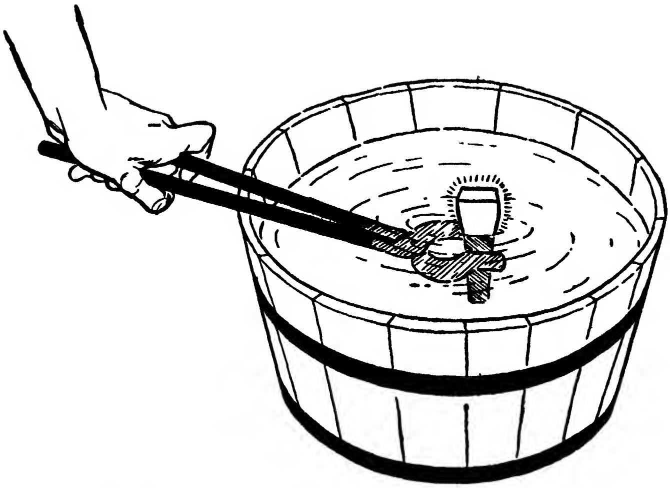


Fig. 14-22. When it is desired to have only a portion of an iron hot, and the adjoining parts cool, as in upsetting, it may be necessary to heat a larger portion and then cool back to the desired point by dipping in water.

be easily upset by ramming the hot end against the face or the side of the anvil.

Points on forging

1. A clean, deep, compact fire is the first requirement for good blacksmithing.
2. Put the irons in the fire in a horizontal position—never point them down into the fire.
3. Always work the irons at a good forging heat—a bright-red or nearly white heat for mild steel.
4. In bending, use bending or leverage blows—not mashing blows.
5. In drawing, strike square, direct blows straight down—not forward-pushing or glancing blows.
6. In drawing round rods, always make them square first and do the drawing while they are square. When they are drawn sufficiently, make them eight-sided and finally round.
7. To smooth up a round rod, roll it slowly on the anvil while striking a series of light, quick blows.
8. In pointing rods, work on the far edge of the anvil. Raise the back end of the rod and strike with the toe of the hammer tilted down.
9. In upsetting use a high heat, and strike extra-heavy blows.
10. To make a good twist, have the section to be twisted at a uniform temperature.

11. In cutting on the hardy, be careful not to let the hammer strike the cutting edge.
12. Use the chipping block for cutting with the cold chisel—not the flat face of the anvil.
13. Strike light hammer blows with wrist motion only; medium blows with motion from both the wrist and the elbow; and heavy blows with motion from the shoulder, wrist, and elbow.
14. Blacking a forging gives it a better appearance and provides some protection against rust. To black, simply rub the piece with an oily rag when it is just hot enough to make the rag smoke.

7. WORKING TOOL STEEL

One of the main advantages of having a forge in the farm shop is to be able to redress and make and temper tools like cold chisels, punches, screw drivers, picks, and wrecking bars. Tool steel for making cold chisels and punches and similar tools may be bought from a blacksmith or ordered through a hardware store; or it may be secured from parts of old machines, such as hay-rake teeth, pitchfork tines, and axles and drive shafts from old automobiles.

Heating tool steel Always heat tool steel slowly in a clean, deep coke fire. Uneven heating, which is usually caused by heating in a poor, shallow fire or by too rapid heating, results in unequal expansion, which, in turn, may cause internal flaws or weaknesses in the steel.

Never heat tool steel above a bright-red or low-orange heat, and heat to this temperature only for heavy hammering. Heating higher is likely to cause the steel to become coarse-grained and weak, rather than fine-grained and strong. In case a piece of tool steel is heated a little too hot, the grain size may be restored by (1) allowing it to cool slowly and then reheating, being careful not to overheat it again, or (2) by heavy hammering at a bright-red or low-orange heat.

Forging tool steel It is important to observe the following points when forging tool steel:

1. Do not hammer below a red heat, as this may cause cracking and splitting.

2. Be sure tool steel is uniformly heated before it is hammered. Otherwise, the outside parts, which are hotter, may stretch away from the inside parts, which are colder, and thus cause internal flaws.
3. Avoid very light hammering, because this may draw the outer surface without affecting the inner portions.
4. Do as much forging as possible by heavy hammering at a bright-red or low-orange heat, as this will make the grain size smaller and thus refine and improve the steel.

Annealing tool steel It is best to anneal a tool, or soften it, after it has been forged and before it is hardened and tempered. This is to relieve strains that may have been set up by alternate heating and cooling and by hammering. To anneal a tool, heat it to a uniform dark-red heat and place it somewhere out of drafts, as in dry ashes or lime, and allow it to cool very slowly.

Hardening and tempering tool steel If tool steel is heated to a dark red and then quenched (cooled quickly by dipping it into water or other liquid), it will be made very hard. The degree of hardness will depend upon the carbon content of the steel and the rapidity of cooling. The higher the carbon content, the harder it will be; and the more rapid the cooling, the harder it will be.

A tool that is hardened in this manner will be too hard and brittle and must be tempered or softened somewhat. This may be done by reheating the tool to a certain temperature (always lower than the hardening temperature) and quickly cooling it again. The amount of softening (or tempering) accomplished will depend upon the temperature to which the tool is reheated. For practical purposes in the farm shop, these temperatures are judged by the color of the oxide or scale on the steel as it is being reheated. A straw color, for example, indicates a comparatively low temperature, and if the tool is quenched on this color, it will be softened only a little. A blue color, on the other hand, indicates a higher temperature, and if the tool is quenched on this color, it will be made considerably softer.

Different grades of tool steel will have different degrees of hardness when quenched at the same color. Therefore, it may be necessary to experiment a little with the first piece of a new lot of steel in order to secure the desired degree of hardness.

Hardening and tempering a cold chisel After a cold chisel is forged and annealed, it may be hardened and tempered as follows:

1. Heat the end to a cherry red, back about 3 in. from the cutting edge.
2. Cool about half of this heated part by dipping in clean water and moving it quickly up and down and sideways until the end is cold enough to hold in the hands (see Fig. 14-23A).
3. Quickly polish one side of the cutting end by rubbing with emery cloth, a piece of an old grinding wheel, a piece of brick, or an old file (see Fig. 14-23B).

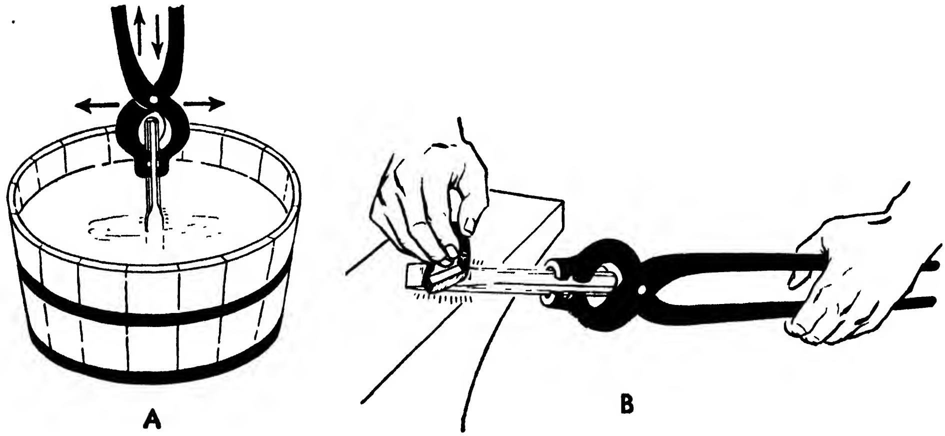


Fig. 14-23. Tempering a cold chisel: A, first heat about 3 in. on the end to a cherry red. Then cool about half the heated portion, moving the tool rapidly up and down and sideways, to avoid too sharp demarcation between hot and cold parts. B, then quickly polish the cooled end with emery cloth or other abrasive to enable the colors to be seen. When the dark blue appears at the cutting edge, dip the end again, working it about, keeping the end cold while any heat left up in the shank is allowed to dissipate slowly.

4. Carefully watch the colors pass toward the cutting end. The first color to pass down will be yellow, followed in turn by straw, brown, purple, dark blue, and light blue.
5. When the dark blue reaches the cutting edge, dip the end quickly into water and move it about rapidly. If much heat is left in the shank above the cutting edge, cool this part slowly so as not to harden the shank and make it brittle. This is done by simply dipping only the cutting end and keeping it cool while the heat in the shank above slowly dissipates into the air.
6. When all redness has left the shank, drop the tool into the bucket or tub until it is entirely cool.

When the tool is first dipped, it is important that it be moved up and down to prevent the formation of a sharp line between the hardened and unhardened parts, as such a line might cause the tool to break at this point sometime later when in use.

If the colors come down too rapidly, the tool may be dipped into the water and out again quickly to retard their movement. When they move down slowly, it is easier to watch them and do a good job of tempering.

Dipping the end at the beginning of the hardening and tempering process makes it very hard. The heat left up in the shank of the tool, however, gradually moves down to the cutting end and softens it; and when it is softened to the desired degree of hardness, as indicated by the color, the tool is then quickly quenched to prevent any further softening. The various colors are simply indications of different temperatures.

If a tool is tried and found to be too soft, as indicated by denting, it should be retempered and the final quenching made before the colors have gone out quite as far as they did originally, that is, before the end has been softened quite as much. If a tool proves to be too hard and the edge chips or crumbles, it should be retempered and the colors allowed to go out a little further.

Tempering punches, screw drivers, and similar tools Tools like punches, screw drivers, and scratch awls may be tempered in the same manner as a cold chisel but may be made harder or softer according to the requirements of the tool. A scratch awl should be made somewhat harder than a cold chisel, a rock drill somewhat harder, a center punch just a little harder, a punch for lining up holes somewhat softer, a screw driver somewhat softer, etc.

Tempering knives Knives and tools with delicate parts are usually hardened and tempered in a manner slightly different from that used for cold chisels, in order to avoid the danger of overheating and warping and to ensure uniform hardening and tempering of the cutting edges.

After a knife blade is forged, anneal it. Then heat it slowly and uniformly to a dark red. Then cool it quickly by dipping the blade edgewise, *thick edge first,* in clean tepid water or oil. This method of cooling helps to ensure uniform cooling and therefore uniform hardening and freedom from warping. Next polish the blade and then reheat it by

drawing it back and forth through a flame or by laying it against a large piece of red-hot iron and turning it frequently to ensure uniform heating. When the desired color, usually blue, appears, quickly cool the blade again by dipping edgeways in the water or oil.

Another method of heating knives and similar tools for hardening and tempering is to draw them slowly back and forth inside a pipe in a forge fire. The pipe must first be uniformly heated in a big fire and then turned frequently to keep it uniformly heated on all sides. Do not allow the knife to touch the pipe.

Points on working tool steel

1. Use a clean, deep coke fire for heating tool steel, and heat it slowly and evenly.
2. Heating in a poor, shallow fire, or heating too rapidly, is likely to cause uneven heating, which results in unequal expansion, which in turn may cause internal flaws or cracks.
3. Proper hammering of tool steel at the proper temperature refines it, making the grain size smaller.
4. Do not hammer tool steel unless it is at least at a dark-red heat and heated uniformly clear through.
5. Hammering below a red heat is likely to cause cracking and splitting.
6. Hammering when not heated clear through may cause the outer parts to stretch away from the inner parts and cause internal flaws or cracks.
7. Avoid light hammering even when the steel is well heated, because of the danger of drawing the outer surface without affecting the inner parts.
8. Never heat tool steel above a bright-red or low-orange heat, and then only for heavy hammering.
9. For moderate hammering, as in finishing and smoothing a job, do not heat above a dark red.
10. Tool steel is ruined if it gets white hot.
11. In case tool steel is accidentally overheated somewhat, allow it to cool slowly and then reheat, being careful not to overheat it again; or heat it to a bright-red or low-orange heat and forge by heavy hammering to restore the fine grain size.

12. After a tool is forged, anneal it by heating to a uniform low red and placing it in dry ashes or similar material to cool slowly.
13. In quenching a tool like a cold chisel, move it rapidly up and down and around, to prevent a sharp line of demarcation between the hot and cold parts.
14. Tempering colors should move slowly so they may be easily seen. If they move too fast, dip the tool quickly into water for an instant.
15. In the final quenching of a tool like a cold chisel, cool the end quickly but dissipate any heat left in the shank very slowly. Otherwise, the shank may be hard and brittle.
16. If a tool is found to be too hard, retemper it and allow the temper colors to go out a little further before final quenching.
17. If the tool is too soft, quench before the colors go so far.

JOBS AND PROJECTS

1. Make a list of blacksmithing equipment that would be suitable for a home farm shop in your community. Consult catalogues and specify model numbers, makes, sizes, and prices.

2. Obtain a piece of railroad iron or rail, and make a suitable mounting for it, so that it may serve as a lightweight anvil.

3. Make a list of the principal forging operations or processes, like bending, which are done frequently in blacksmith work. List for each operation two or three of the most important points to be observed in performing it.

4. Make a list of several small forged appliances, such as meat hooks, gate hooks, hay hooks, and eye bolts. Consult shop books and manuals for suggestions. Select a few that involve most of the common forging operations, and that you would like to make and use about your home or farm.

5. Make plans, including lists of materials, for the jobs selected in No. 4 above and proceed to make them.

6. Make an inspection of a few farm machines, like plows, cultivators, and planters, and make a list of such parts as straps, irons, rods, and clevises that need repairing or replacing. Sketch the parts to be made, or plan the repairs, and make them.

15 PIPEWORK AND SIMPLE PLUMBING

NOT MANY tools are required to do a moderate amount of pipework and simple plumbing. Many jobs can be done with only one or two pipe wrenches and the common woodworking and metal-working tools in a shop. If a considerable amount of piping is to be installed or kept in repair, it might be advisable to have some pipe-cutting and threading equipment. For the occasional job, pipe may be bought already cut to the desired length and threaded, so that all that is necessary is to assemble the pipes and fittings.

1. SELECTING PIPE TOOLS FOR THE SHOP

Wrenches Every farm shop should have at least one pipe wrench, preferably two, even if very little pipework is to be done. Pipe wrenches

are useful for holding and turning round rods and various machine parts, as well as pipes. Wrenches of 14- and 18-in. size are most useful, and wrenches with all-steel handles (see Fig. 15-1) are usually better for farm work than those having wooden grips.

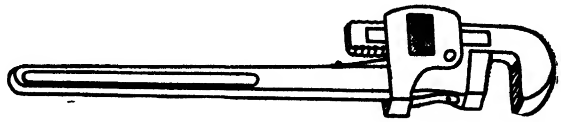


Fig. 15-1. Every well-equipped farm shop should have at least one pipe wrench, preferably two.

Vise Probably the most practical kind of vise for holding pipes in farm shops is a regular blacksmith's or machinist's vise equipped with auxiliary pipe jaws. Where considerable pipe work is to be done, a regular pipe vise may be advisable. For an occasional job, pipe can be held in an ordinary flat-jaw vise with the aid of a pipe wrench by cramping the handle against the side of the bench (see Fig. 15-2).

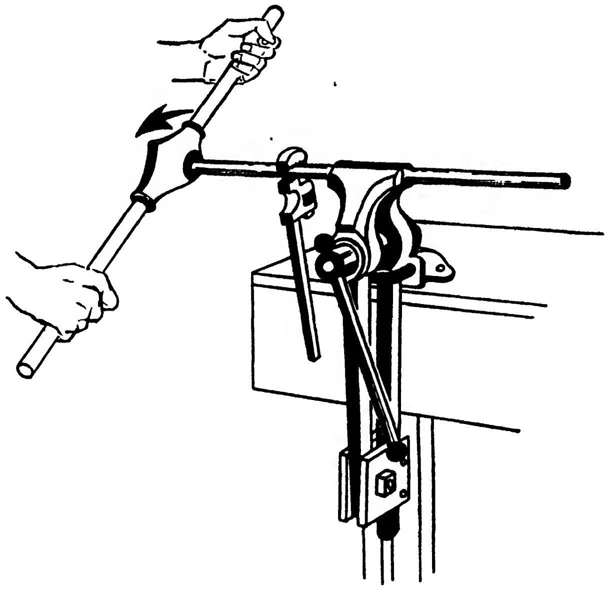


Fig. 15-2. For an occasional job of pipework, the pipe can be held in an ordinary vise with the aid of a pipe wrench.

Pipe cutter For an occasional job of pipe cutting, a hack saw is quite satisfactory. Where considerable pipe is to be cut, a pipe cutter will be better and more economical.

Dies and taps A set of pipe dies will be needed only when a large job of pipe fitting, such as installing a water system, is undertaken, or when considerable pipework is to be kept in repair. Pipe dies and taps in the two smallest sizes (⅛ and ¼ in.) may be justified for such work as repairing grease and oil pipes on machinery and engines.

Sets of pipe-threading tools do not normally include taps, as pipe fittings that screw onto pipes are threaded at the factory, and therefore there is little use for taps.

One-piece dies are generally preferred to two-piece dies, because of the ease with which they may be changed in the stock. A stock with a ratchet handle is much easier to use than a plain stock for threading any but the smallest sizes of pipe. The ratchet handle can be worked

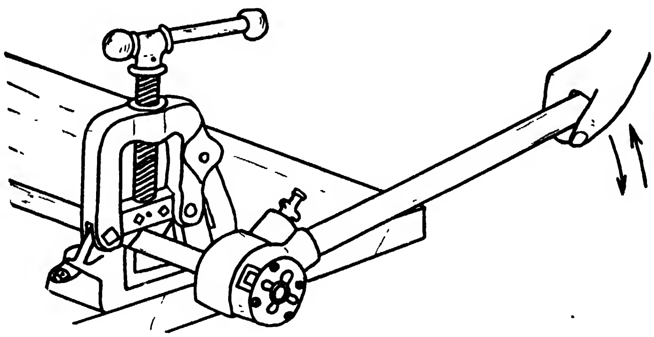


Fig. 15-3. The ratchet die, although more expensive than the plain die, is much easier to operate and is preferred by many mechanics.

back and forth through that portion of the turn where force can be best applied. Ratchet equipment costs more, however, and for an occasional threading job, the extra expense may not be justified.

2. SELECTING PIPE AND PIPE FITTINGS FOR A JOB

Pipe is available in either black or galvanized iron. Black pipe is used for oil, air, or gas. Galvanized pipe should be used for a water-supply system. Galvanized pipe will of course last longer when used under conditions that tend to cause rusting and corrosion.

Pipe fittings are made of cast iron or wrought iron. Wrought-iron fittings are available in either black or galvanized finish.

In selecting or buying pipe, be sure to get the right size. The size of a pipe is designated by its *inside* diameter. The actual inside diameter of

a pipe, however, is slightly larger than its nominal or designated size. For example, a ½-in. pipe measures actually a little more than ½ in. in diameter. Pipe is made in sizes ranging from ⅛ to ½ in. by steps of ⅛ in., and from ½ to 1½ in. by steps of ¼ in.

The size of a pipe fitting is designated by the size of the pipe upon which it fits, and not by the diameter of the fitting itself. For example, a ½-in. elbow has an inside diameter of about ¾ in., but it is called a ½-in. elbow because it fits on the outside of a ½- in. pipe.

Selecting pipe fittings There are on the market many different pipe fittings. By careful planning and selection of fittings, a particular

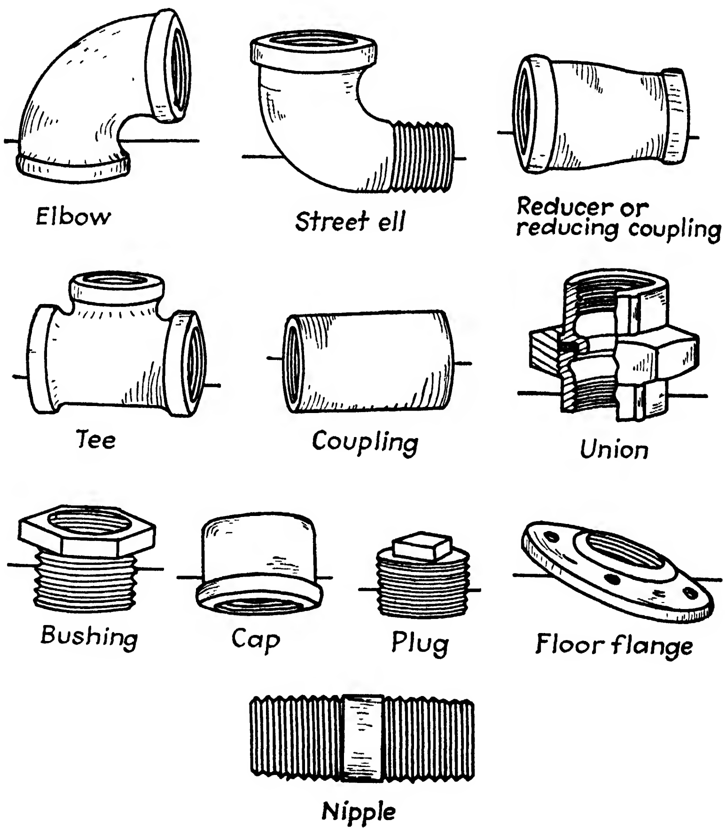


Fig. 15-4. Common pipe fittings.

job may often be simplified and made easier. The most common pipe fittings are illustrated in Fig. 15-4 and their uses described in the following paragraphs.

The *coupling* is simply a short sleeve threaded on the inside at both

ends and is used for joining two pieces of pipe in a straight line, where at least one of the pieces can be turned.

The *union* is used for joining two pipes where neither can be turned. It consists of three pieces, one to screw onto each of the two ends being joined, the third part being a nut for drawing the other two parts tightly together. There are two general kinds of unions, one that requires a gasket to make a tight joint, and one that does not. The parts of a union that requires no gasket fit together much as an engine valve fits into its seat.

A *nipple* is simply a short piece of pipe threaded on both ends.

The *elbow* or *ell,* is used for making right-angle turns in a line of pipe. A 45-deg elbow is used for making a turn of 45 deg.

The *street ell* is similar to the ell, except it has one end threaded on the outside, so that it may be screwed *into* a fitting such as a tee. It can be used instead of an ell and a short nipple. It is also frequently used in piping to give a certain degree of flexibility to allow a limited movement of parts without causing undue strain on the joints (see Fig. 15-11).

A *tee* is used for joining a side branch to a main line of pipe.

A *reducing coupling* is a coupling with one end made to fit one size of pipe, and the other end a different size.

A *bushing* is a short sleeve used to reduce the size of a threaded opening. It is threaded on the inside, and also on the outside at one end. The other end is usually hexagon-shaped to receive a wrench.

A *cap* is used to screw over the threaded end of a pipe, thus stopping it.

A *plug* is used to screw into a threaded opening, such as one outlet of a tee, and thus stop the opening.

A *floor flange* is used for fastening the end of a pipe to a wall or floor, as in stair rails.

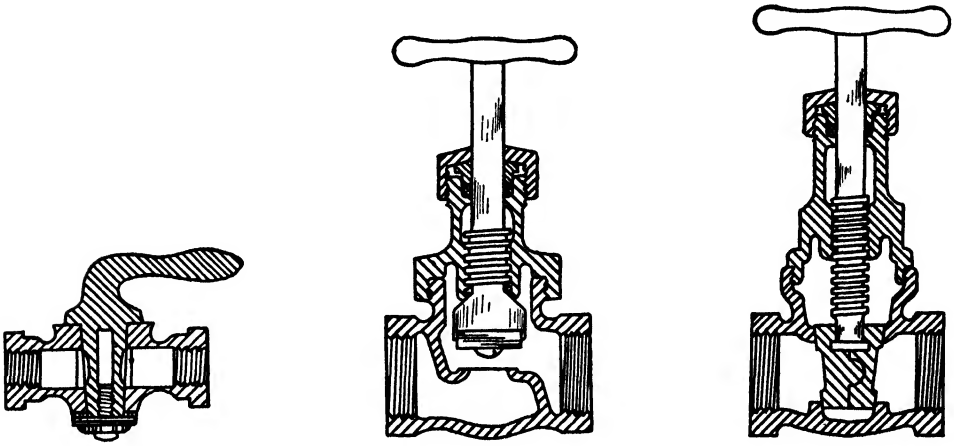
Selecting pipe valves and faucets The most commonly used pipe valves and faucets are as follows:

A *stop-and-waste cock* (Fig. 15-5*A*) is commonly used in a supply pipe. When it is turned off, it allows the water in the pipes beyond the cock to drain out.

The *globe valve* (Fig. 15-5*B*) is the most commonly used type of shutoff valve. In passing through it, the water must make two right-angle turns. It should be installed so that when it is turned off there will be

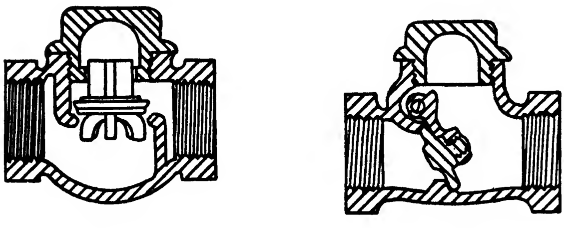
no pressure on the packing around the valve stem. This not only lessens the possibility of leakage around the stem, but it also enables the stem to be repacked without turning off the pressure on the whole line.

The *gate valve* (Fig. 15-5*C*) offers less resistance to the passage of water through it than does the globe valve; but it is not so easily repaired and is used less. It is used in places where it is important not to impede



A B C

Fig. 15-5. Shutoff valves: *A*, stop-and-waste cock; *B*, globe valve; *C*, gate valve.



A B

Fig. 15-6. Check valves: *A*, lift type; *B*, swing type.

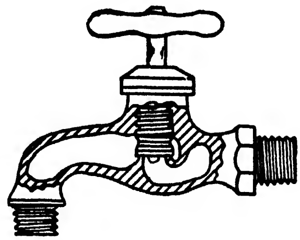


Fig. 15-7. A compression bib faucet.

the flow and where the valve would have to be closed only rarely, such as at a pump or storage tank where the valve would need to be closed only when repairs are made on the system. In a gate valve, the flow is stopped by lowering a wedge-shaped gate into a seat.

A *check valve* (Fig. 15-6) is used to prevent a backflow in a pipe. Two general styles are in common use, the lift valve and the swing valve.

The *compression bib* (Fig. 15-7) is the most common type of faucet. In principle it is very similar to the globe valve. When it is closed, a composition disk is held against a seat. When the disk becomes worn, it is easily replaced or turned over.

3. MEASURING AND CUTTING PIPE

To ensure a good job and to prevent waste of materials and time, it is always advisable to take measurements before doing any cutting. If the job is a large one and involves the use of many parts or joints, first make a sketch to show dimensions and kinds of fittings to be used. Careful planning often makes it possible to get along with fewer joints and fittings and consequently with less expense and work. Many small jobs of pipework may be done on the farm even though pipe-threading tools are not available in the farm shop. In such cases, simply take accurate measurement of the lengths of pipe needed and then buy the pipe already cut to length and threaded. In measuring or cutting pipe to fit into a given place, be sure to take into account the distance which the pipe will screw into the fittings on its ends.

Cutting pipe with a hack saw In cutting pipe with a hack saw, careful work is required to avoid catching and breaking out some of the teeth or breaking the blade. Use a medium- or fine-toothed blade (18 or 24 teeth per inch). It is a good plan when measuring to indicate the places to be sawed by filing a notch with a file. Such a notch not only marks the place distinctly, but helps to start the saw exactly at the right place. Use moderate pressure on the saw blade and make long, moderately slow strokes. Release the pressure on the backstrokes. Keep the blade stretched tight in the saw frame, and be careful to keep the saw cutting square with the pipe. See Chap. 12, "Cold-metal Work," pages 373 to 381 for further suggestions on the use of hack saws.

Cutting pipe with a pipe cutter A pipe cutter leaves a smoother end on the pipe than a hack saw, although it forms a burr inside the pipe that should be removed for most pipework.

To use a pipe cutter, place it carefully on the pipe so that the cutting wheel engages the pipe at exactly the place to be cut (see Fig. 15-8). Tighten the wheel against the pipe by screwing the handle.

Apply threading or cutting oil and turn the cutter around the pipe, tightening the handle a little once each turn to force the cutting wheel into the pipe.

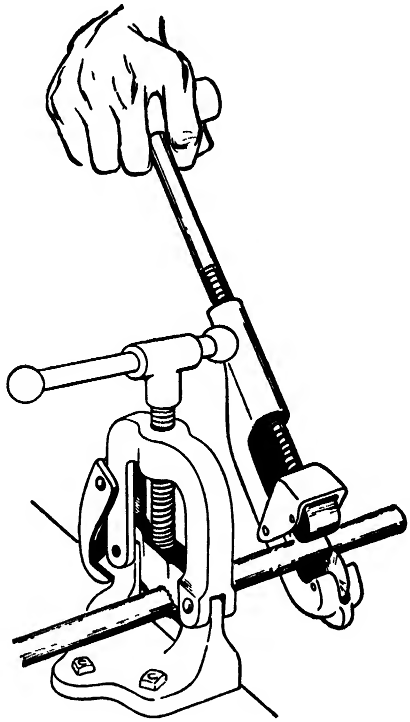


Fig. 15-8. Cutting pipe with a pipe cutter. Although a hack saw is satisfactory for an occasional job of pipe cutting, a pipe cutter is recommended where much pipework is to be done.

4. REAMING PIPE

After the pipe has been cut with a pipe cutter, it should be reamed to remove the burr left on the inside by the cutter, if it is important that the carrying capacity of the pipe not be reduced. The best way of removing this burr is to use a reamer in a carpenter's brace (see Fig. 15-9). For an occasional job when a reamer is not at hand, the burr may be removed with a round or half-round file.

5. THREADING PIPE

To thread a pipe, first clamp it securely in a vise. If a pipe vise is not available, a flat jaw vise and a pipe wrench may be used (see Fig. 15-2). Select the proper size of collet (guide) and die, and insert them in the stock. Place the die on the end of the pipe, and exert

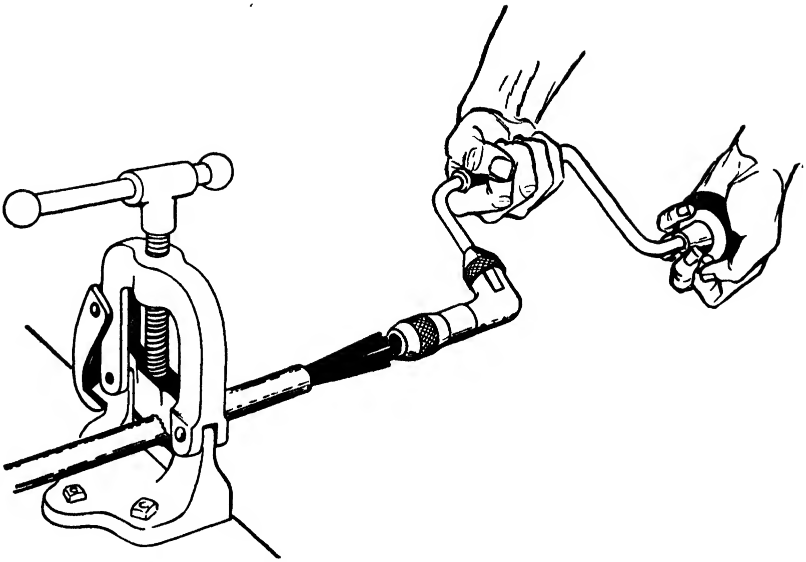


Fig. 15-9. Reaming the inside of a pipe to remove the burr left by the pipe cutter. The burr may be removed with a round or half-round file if a reamer is not available.

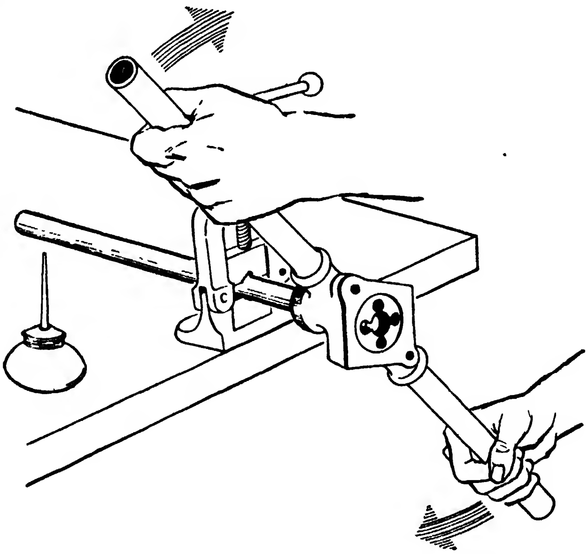


Fig. 15-10. Threading pipe. Keep the die lubricated with lard oil or threading oil. Stop and back the die off when about one thread projects through.

considerable pressure while the die is slowly turned. As soon as the die starts to cut and thread itself onto the pipe, stop and apply threading or cutting oil. Then continue to turn the die onto the pipe until about one thread projects through the die. If the die is screwed on further, the end of the pipe that projects through will have straight

threads instead of tapered threads. (Pipe threads are tapered so that they will tighten securely as they are screwed into fittings.)

After the die has been screwed far enough onto the pipe, simply stop and turn it back off. Shake the cuttings from the die, as they may interfere with threading the next pipe. When finished with the die, wipe it with a cloth to clean it before putting it away.

6. ASSEMBLING PIPE AND PIPE FITTINGS

Assembling pipes to avoid strain Pipes should be assembled so as to avoid strains and bending at the joints wherever possible. Figure 15-11 illustrates a method of using a street ell in combination with an ell to allow slight movement of the pipes without placing undue strain

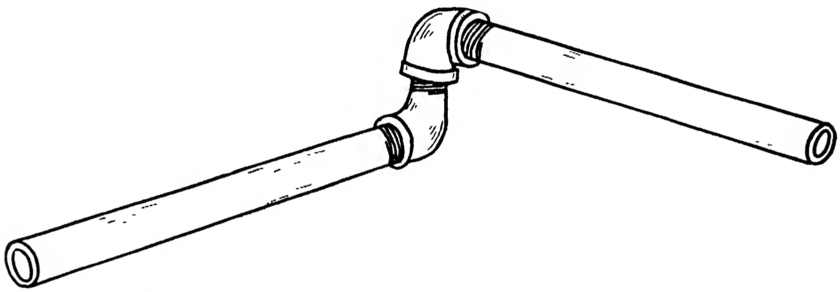


Fig. 15-11. A street ell in combination with an ell used to form a sort of "universal joint" to allow slight movement of the pipes without placing undue strain on them.

on the joints. This method is especially good for aligning pipes and connecting a water tank to a pump or a pipe line, or a gas stove or heater to a pipe line.

Using thread compound To ensure tight joints in pipework, coat the threads with some kind of thread or pipe compound before screwing them together. A commercial compound, thick paint, a mixture of graphite and heavy grease, or a paste of portland cement and linseed oil may be used. Thick paint is all right for rather permanent work, but it is not so good if the joints may need to be taken apart frequently.

Pipe compound may be applied to the threads on the end of the pipe, or to the threads inside the fitting, or both. If the compound would be objectionable inside the pipe, apply it only to the threads on the pipe, and not inside the fitting.

A small, stiff brush is probably best for applying compound to

threads, although for an occasional job a small wooden stick or paddle, or even the fingers, may be used.

Screwing the joints tight Some judgment is required to know just how tight to screw the joints. The threads are tapered, and the farther a joint is turned, the tighter it will fit. Just tight enough to prevent leaking is all that is required. It is possible, particularly on small pipes, to screw the joints too tight, and possibly deform or unduly mar the fittings.

It is a good plan in assembling pipework to use two pipe wrenches, keeping one set to fit the pipe and the other to fit the pipe fittings.

Installing valves When screwing a valve onto the end of a pipe, use the wrench on the end of the valve next to the pipe. This avoids placing strain on the valve which might twist it and thus damage it. Likewise, when screwing a pipe into one end of a valve, place a wrench on the end of the valve receiving the pipe to avoid damaging it.

In order to avoid marring a valve or faucet with wrench marks, use a monkey wrench or other smooth-jaw wrench, wherever possible, rather than a pipe wrench.

7. USING COPPER TUBING

Copper tubing is often used instead of steel piping for water and fuel lines in a building. It is available as soft flexible tubing or as hard-temper rigid tubing. Flexible tubing can be pulled or "fished" through walls and under floors in old buildings where it would be difficult or impossible to use rigid tubing or piping. Flared tube connections and fittings are used in making joints and connections in flexible tubing. Simple tools are used for bending and cutting the tubing and for flaring the ends to fit the fittings. Ordinary wrenches are then used to tighten the fittings and secure the tubing in place.

Hard-temper rigid tubing cannot be bent and worked into place like flexible tubing, but elbows, tees, and similar fittings are readily attached by soldering. A length of tubing is simply cut to length and the end tinned, inserted into the fitting, and soldered into place by sweating. Piping systems of this type are neat and compact and are easy to install.

Copper and brass tubing in the smaller sizes is also used extensively for fuel and oil lines on tractors and other farm machinery.

8. CUTTING A GASKET

Some unions require gaskets to make tight joints. Gaskets are also used in various places on water tanks, heaters, and other pieces of equipment. When fittings are disassembled, gaskets are usually destroyed, and new ones must be used when the parts are reassembled. Gaskets are usually available at hardware stores and plumbing shops, but they

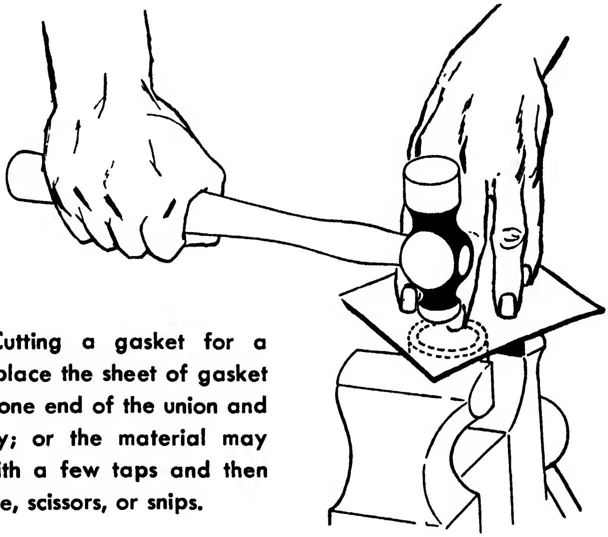


Fig. 15-12. Cutting a gasket for a union. To cut, place the sheet of gasket material over one end of the union and hammer lightly; or the material may be marked with a few taps and then cut with a knife, scissors, or snips.

may be made at home if some suitable material, such as sheet rubber or sheet fiber, is available.

To cut a gasket, place the gasket material over the part it is to fit (see Fig. 15-12) and cut it to shape with light blows from a hammer; or, if preferred, simply mark the gasket material with a few light hammer taps or with a pencil, and then cut it out with a sharp knife, snips, or scissors.

9. REMOVING A SECTION OF DEFECTIVE PIPE

It frequently happens that one length of pipe in a system of pipe work develops a leak, as from freezing, and must be removed. Probably the simplest way to do this is as follows: Cut the defective section in

two, using a hack saw. Then remove the two parts of the defective pipe by unscrewing them, without disturbing any other parts of the system. Cut and thread two or more pieces of pipe to go in the place of the leaky joint, using a union to make the final connection.

10. REPAIRING LEAKY VALVES AND FAUCETS

Leaky faucets and globe valves can usually be repaired by simply replacing the disks or washers that fit down on the seats. To repair such a faucet or valve, turn off the pressure from the pipe line and take the faucet or valve apart. Use smooth-jaw wrenches rather than pipe wrenches or pliers to avoid marring the parts. Once the valve or faucet is apart, the disk or washer can usually be removed by taking out a small screw (see Fig. 15-13). To complete the job, simply install a new disk or washer, clean the various parts, and reassemble them. In case no new washer or disk is at hand, it is sometimes possible to turn the old one over, and make it do for a time longer. It is a good plan to keep an assortment of such valve and faucet disks on hand for repairs.

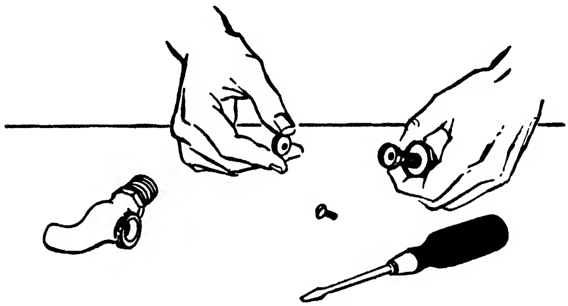


Fig. 15-13. Replacing a faucet disk or washer.

After long use, the seat in a valve or faucet may become pitted or corroded until it will not hold even when a new disk is installed. In such cases, a special valve and faucet seat reamer may be used to smooth the seat. On some types of faucets, it may be possible to remove the old seats and replace them with new ones.

11. REPAIRING PUMPS

There are many different types of pumps used on farms, and the exact method of repairing a particular pump will depend upon the

type of pump and the troubles. The first step in repairing a pump is to study it to determine how it should work and to locate the troubles, if possible, before taking it apart.

Most farm pumps are plunger pumps, with cup-shaped leathers on the plungers to make them fit snugly in the cylinders (see Fig. 15-14). The most common causes of pump trouble are worn leathers and worn

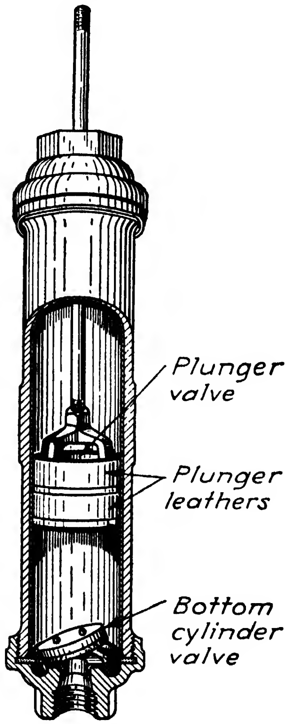


Fig. 15-14. A view showing working parts of a pump cylinder. The most common pump-repair job is the replacement of worn leathers and parts in the pump cylinder.

Fig. 15-15. Some deep-well pumps are so made that the plunger and valves may be withdrawn without removing the whole pump from the well. (The Deming Company)

valves. The most common pump-repair job, therefore, is the replacement of worn leathers and valves.

Pumps are usually not difficult to repair, once they are taken apart and the valves, leathers, and other working parts are accessible. It usually requires much more work to take a pump apart than it does to install the new leathers and other parts. Therefore, whenever a pump is taken apart, it is a good plan to replace all parts that show any appreciable wear, even though they might last considerably longer.

Before taking a pump apart, be sure to have on hand, if at all possible, all leathers and other parts, including any special gaskets, that may be needed. Repair kits for common makes of small automatic motor-driven pumps are often available from dealers. These kits include all leathers, valve washers, gaskets, etc., that may be needed, and if they are available, it is best to have one on hand before starting to overhaul such a pump.

Removing a pump from a well Many farm pumps are so made that the whole pump and pipe must be withdrawn from the well in order to remove the working parts from the cylinder. In such cases, be sure to use safe lifting tackles of some sort. A set of blocks and tackle, chains and pry poles, rope hitches, and so forth, can often be used to advantage. A special safety holder, or a combination lifter and holder, to keep the pipe from slipping back into the well is a valuable piece of equipment when removing a pipe or a pump from a well. Such a holder may be bought or borrowed from a pump dealer, or a similar device may be made in the shop.

Some deep-well pumps have cylinders so made that the plunger and valves can all be withdrawn up through the pump pipe without the necessity of removing the whole pump (see Fig. 15-5). In such cases, disconnect the plunger rod at the top, and allow the plunger to sink gently to the bottom of the cylinder. Then attach the plunger to the bottom cylinder valve, by turning the plunger rod to the right. The bottom cylinder valve can then be withdrawn along with the plunger, by simply pulling up on the plunger rod. The plunger rod is jointed, and sections may be removed as they are lifted from the well.

Taking a pump cylinder apart; installing new leathers Once a pump is removed from the well, proceed to take the cylinder apart. Large, strong wrenches may be required, and considerable patience as well, for the joints often become rusted and are difficult to loosen. Striking a few sharp blows with a medium-sized hammer will often help to loosen a tight joint. Once the cylinder is apart, remove the plunger and the valves and renew all leathers or other worn parts. Plungers themselves are usually taken apart by unscrewing the bottom parts.

To complete the pump-repair job, simply clean all parts and reassemble them carefully. It may be advisable to use pipe compound

on the pipe joints to avoid the possibility of air leaks. It is particularly important to use good gaskets on cylinder heads, valve chamber covers, etc., of small automatic water pumps. Small leaks in pipes and connections often cause loss of prime and erratic or otherwise unsatisfactory operation.

12. TAKING CARE OF AN AUTOMATIC WATER SYSTEM

Many pieces of automatic equipment require so little attention that they are often forgotten or neglected. This is sometimes the case with an automatic water system. The main points in the care and mainte-

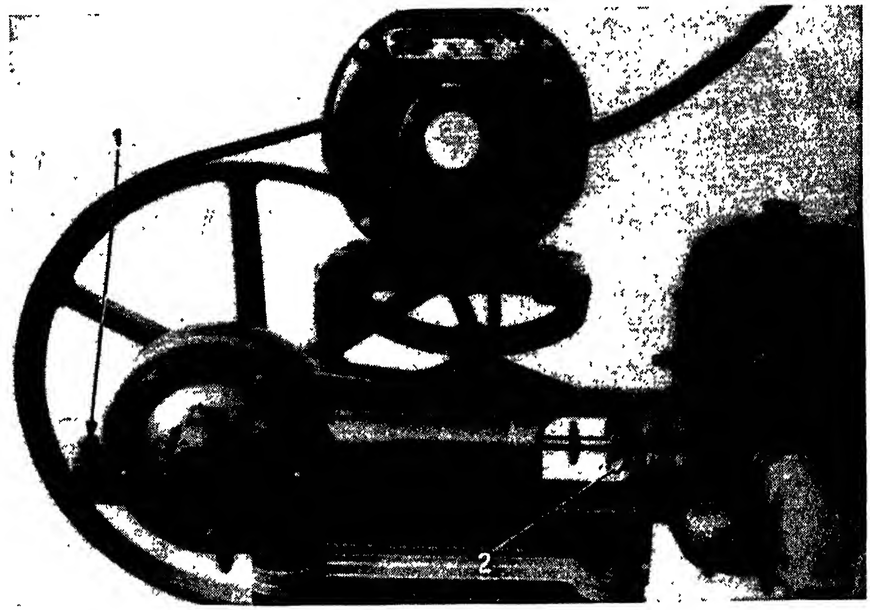


Fig. 15-16. A small automatic water pump. The main points in taking care of such a system are: lubricating the motor, adjusting the belt tension, adjusting the air-intake valve as needed, checking the pump lubrication through oil-filler plug 1, and tightening the stuffing box 2. (General Electric Company)

nance of such a system are (1) lubricating the pump and motor occasionally, (2) tightening the stuffing box, (3) adjusting the air-intake valve (on some systems), and (4) adjusting the belt tension.

Most pumps have oil-level plugs or marks on the side (see Fig. 15-16). Be sure to keep the oil up to the proper level, adding medium-weight motor oil as may be required. A few drops of oil in each motor bearing

once every month or two is usually adequate. For further information on lubricating electric motors, see Chap. 19, "Maintaining Electrical Equipment," page 590.

Check the stuffing box (see Fig. 15-16) occasionally. Keep it tight, but not too tight. A good system is to tighten the stuffing box until it stops leaking, and then unscrew it a half turn or more until it leaks two or three drops a minute. A slight leakage helps to lubricate the piston rod.

For proper operation, a closed water-storage tank must be partly filled with air. The proper water level in the tank is indicated by try cocks or by a water glass on the side. Water absorbs some of the air, and, in time, if the absorbed air is not replaced, the tank will become waterlogged, causing the pump to start often, pump just a little, and then shut off. Some water systems have automatic controls so that the pump pumps a little air along with the water as may be needed to keep the tank properly supplied. On other systems, particularly older models, the operator must open a small air valve on the pump to allow it to replenish the air in the tank and then shut it off after enough air has been pumped. This air valve on the pump is often like an air valve on a tire, and is opened by loosening or removing a cap on the end, and closed by screwing it back on.

Keep the belt tight enough to prevent slippage, but not so tight as to cause undue pressure and wear on the motor and pump bearings. The tension on a V belt is usually about right when the belt can be depressed or pushed in about ¾ in. at a point midway between the two pulleys.

13. INSTALLING A SIMPLE SHOWER BATH

Where hot and cold water are available, and where a drain can be provided, a simple shower bath can be installed with only a little work and expense. If there is a sewer drain in the basement, a shower drain can usually be connected. A trap must be installed in the shower drain. The floor for the shower is usually made of concrete and should have side walls a few inches high to prevent water from running out onto the basement floor.

A shower booth may be constructed on the job, or one may be purchased and installed. Hot- and cold-water lines are then run from existing pipes in the basement to the sprinkler head. Although it would

be somewhat better to have a special mixing valve for the hot and cold water, a plain globe valve in each line will work quite satisfactorily.

JOBS AND PROJECTS

1. Practice cutting and threading a few pieces of pipe until you understand exactly how to do it. Fit a few pieces of pipe together, and test under water pressure if possible.
2. Make a list of pipe or plumbing repair jobs that need to be done about your home or farm. Also list any simple extensions to an existing water system that would save time and labor in doing chores or in taking care of livestock.
3. Make plans and actually perform some of these repair jobs, or make an extension if it can be arranged.
4. Renew the disks on some leaky faucets, either about your home or farm or about the school or shop.
5. Take a pump cylinder apart, and renew the leathers and any valve parts that are worn.
6. Make a plan for a basement shower, listing all materials and supplies needed, together with sizes, kinds, costs, etc.
7. If possible, install a shower according to a plan previously made.

16 ELECTRIC ARC WELDING

1. Selecting an Arc Welder for the Farm
2. Selecting Electrodes for Farm Welding
3. Selecting Arc-welding Accessories
4. Using Safety Measures in Arc Welding
5. Striking an Arc and Running a Bead
6. Making Butt Welds in the Flat Position
7. Making Fillet Welds in Flat and Horizontal Positions
8. Welding in Vertical, Horizontal, and Overhead Positions
9. Arc Welding Cast Iron
10. Arc Welding High-carbon Steel
11. Building Up Worn Parts; Hard Surfacing
12. Cutting Cast Iron and Steel with the Electric Arc
13. Controlling Expansion and Contraction
14. Using the Carbon Arc Torch

WELDING equipment is quite valuable in the farm shop and is considered indispensable on many modern farms. With it many useful appliances and much needed equipment can be made, but it is probably most valuable for quickly making emergency repairs on farm machines. Many broken parts may be repaired in place, whereas without welding equipment it would be necessary to remove the broken part and take it to a commercial welding shop or to replace it with a new part, either of which would require considerably more time and labor, as well as out-of-pocket expense.

Electric arc welding equipment is preferred by many over gas welding equipment, because of the speed and ease with which welds may be made. Electric welding equipment is more expensive to buy than oxyacetylene welding equipment, but operating costs are lower. See Chapter 17, "Oxyacetylene Welding and Cutting," page 524, for further comparisons of electric and oxyacetylene welding.

While skilled workmanship may be desirable in farm welding, it is not an absolute requirement. Many farmers and other inexperienced mechanics, with only a little practice, are able to make welds on farm equipment that are entirely satisfactory, even though they would not meet the standards of production welding in factories.

In arc welding, the intense heat of the electric arc is used to fuse the parts being joined. The principal kind of arc welding done in farm shopwork is known as *metallic arc welding.* A heavy current is made to flow across a small gap between the end of a shielded or specially coated metal electrode, or welding rod, and the metal being welded. The heat of the arc that spans this gap is so intense that it instantly creates a crater, or small puddle of molten metal, on the work, and also melts small globules of metal from the end of the electrode. These molten globules pass through the arc and are added to the puddle (see Fig. 16-1). As the electrode is slowly moved along a joint, a weld is made.

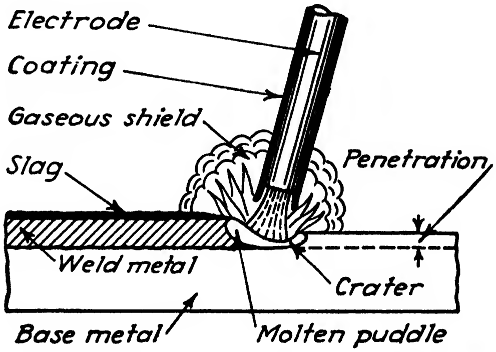


Fig. 16-1. Arc welding with shielded or coated type of electrode.

In another kind of arc welding, known as *carbon arc welding,* the current passes from the end of a carbon electrode to the work and quickly heats it to a welding temperature. A metal filler rod is used, as in oxyacetylene welding. Carbon arc welding is seldom used in farm shopwork.

1. SELECTING AN ARC WELDER FOR THE FARM

Two general types of electric arc welders are available, direct-current (d-c) and alternating-current (a-c). A d-c welder is essentially a special electric generator driven by a gas engine or by an electric motor, usually of the a-c three-phase type. An a-c welder is a special transformer which operates from an electric power line. A-c welders are generally used for farm welding. They can be used, of course, only where alternating current is available, and their use is therefore limited principally to the shop or other points about the farmyard where heavy-duty power outlets are installed.

Where a portable welder is desired, and considerable welding is to be done, possibly including some custom work, it is well to consider the purchase of an engine-driven d-c welder, even though it is considerably more expensive than an a-c welder.

With an a-c welder, the welding current through the arc continually alternates or reverses 120 times per second (on 60-cycle current),

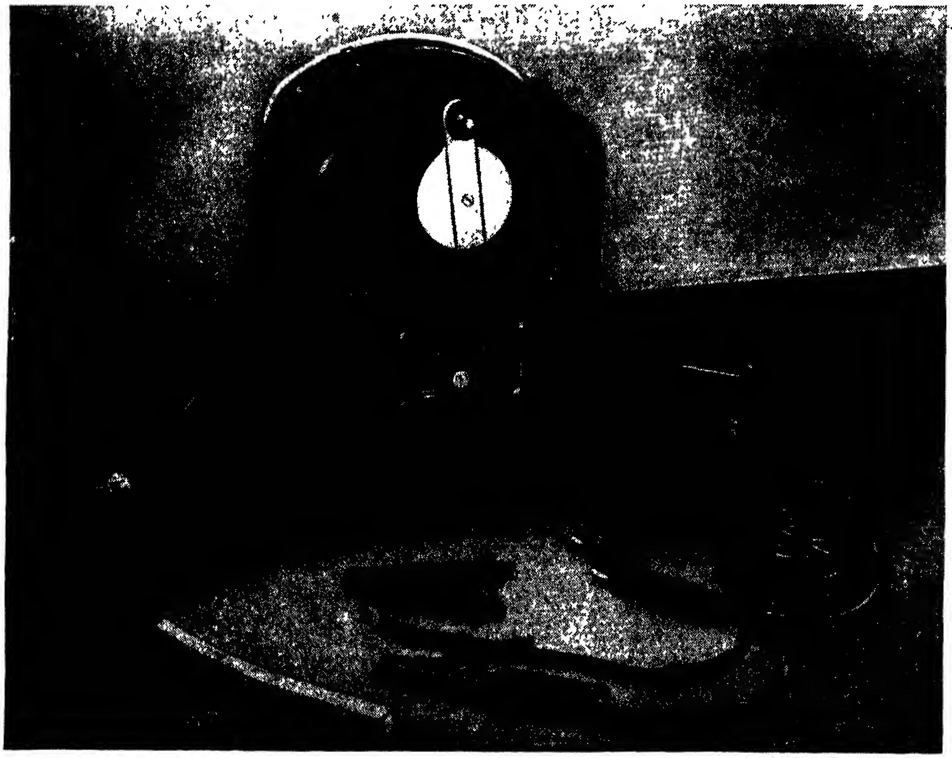


Fig. 16-2. The a-c transformer type of electric-arc welder is the type most commonly used in farm shopwork. (James F. Lincoln Arc Welding Foundation)

whereas the current in a d-c arc flows in one direction. The direction of flow can be quickly changed, however, by changing a switch on the welder or by interchanging the connections to the ground and electrode cables. The setting is known as *straight polarity* when the work is positive and the electrode is negative, and as *reverse polarity* when the electrode is positive and the work is negative. Straight polarity (work positive and electrode negative) is generally used for welding mild steel, because there is more heat liberated on the positive side of the arc, making it easier to obtain deep penetration. There is considerable

advantage, however, in being able to use reverse polarity for some work, as in welding thin steel and cast iron and in overhead welding, where less heat is desired on the work. Some electrodes are designed for straight polarity, some for reverse, and some for either. It is important, therefore, that the machine be set to give suitable polarity for the electrode being used and the kind of welding being done.

Selecting for size Welders are rated according to their current output in amperes. A-c welders of 180-amp capacity of the so-called *limited-input type* are most commonly used on farms. Welders in both

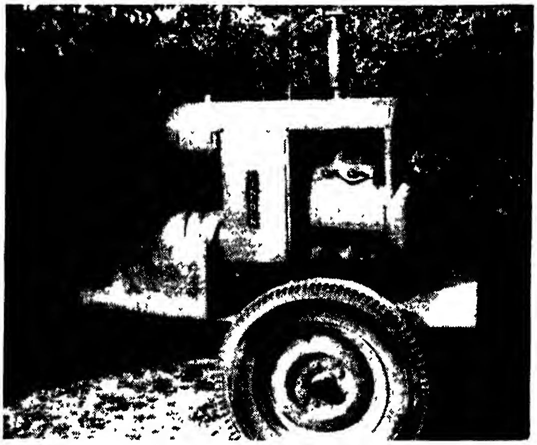


Fig. 16-3. A portable engine-driven d-c welder may be used for welding away from the shop.

smaller and larger sizes are available and are sometimes used, but smaller ones weld more slowly and are not so good for cutting. Larger sizes are seldom needed, as most of the farm welding is done with 125 to 160 amp. Another consideration restricting the use of larger welders is that many rural electric lines are limited in their capacity to supply them satisfactorily, and further, many farms have only 3-kilovolt-ampere transformers, which are not large enough for larger welders.

The Rural Electrification Administration (REA) and the National Electric Manufacturers Association (NEMA) have adopted certain specifications or standards for farm welders, and in purchasing a welder it would be well to make sure that it meets these standards. The welder should also bear the seal of approval of the Underwriters' Laboratories, indicating that it meets the standard safety requirements.

Installing an electric welder A 230-volt outlet with its own disconnect switch and fuses is needed for the farm welder, and it should be properly grounded. The instructions regarding types and sizes of wire, switches, fuses, and ground connection which come with the welder should be carefully followed. The installation should be made or supervised by a competent electrician or mechanic.

Locate the welder where it will be convenient for doing welding on machines and equipment brought into the shop, usually near the door.

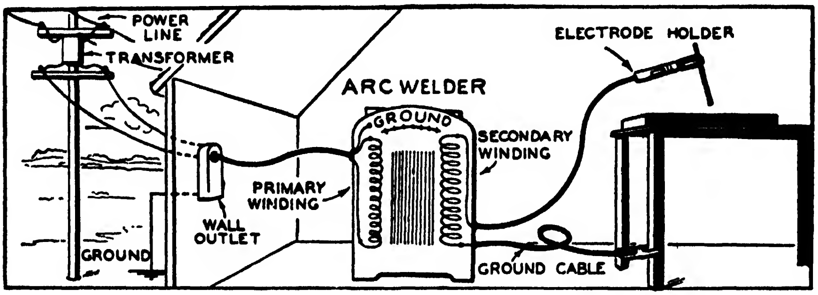


Fig. 16-4. The a-c arc welder takes power from the electric line and transforms it into low-voltage heavy current suitable for welding. (James F. Lincoln Arc Welding Foundation)

Place it on a dry floor, preferably of concrete, to avoid danger of fire or electric shock, and where flammable materials such as wooden equipment, shavings, hay, fuels, or oils can be easily kept away.

2. SELECTING ELECTRODES FOR FARM WELDING

There are many kinds and types of electrodes available to suit a variety of welding conditions. These electrodes differ principally in the kind of metal from which they are made, and in the kinds and amounts of ingredients used in the coatings. Heavily coated electrodes are commonly used in farm welding. The coating of such an electrode melts and burns and provides a gaseous shield for the arc and also a thin slag covering for the weld. It thus keeps out oxygen and nitrogen from the air and prevents the formation of harmful oxides and nitrides in the weld, which would cause it to be weak and brittle. The materials in the coating also have important influences on the stability of the arc, its force and direction, and its penetration, and also on the shape of the weld bead, whether flat, convex, or concave. The development of a-c welding, particularly with the limited-input type of farm welder, was made possible largely by the development of suitable electrode coatings.

TABLE 16-1. Electrode Characteristics

AWS No.	Type of current	Application: characteristics	Color identification	
			Primary color (end)	Secondary color (side)
E6010	d-c reversed polarity (electrode positive)	Low- and medium-carbon steel, all positions, deep penetration, thin slag, moderate spatter	None	None
E6011	a-c or d-c reversed polarity (electrode positive)	Low- and medium-carbon steel, all positions, deep penetration moderate spatter	None	Blue
E6012	d-c straight polarity (electrode negative) or a-c	Low- and medium-carbon steel, all positions, for poor fit-up, medium penetration, slight spatter	None	White
E6013	a-c or d-c straight polarity (electrode negative)	Low- and medium-carbon steel, all positions, general purpose, medium penetration, moderate spatter	None	Brown
E6016	a-c or d-c reversed polarity (electrode positive)	High-carbon steel (bumpers, disk blades, springs), all positions, deep penetration, low spatter, iron	None	None
Cast iron or steel for cast iron (No AWS number)	a-c or d-c	Cast iron where weld will not need to be machinable	Orange	None
Nickel alloy for cast iron (No AWS number)	a-c or d-c	Cast iron where weld will need to be machinable	Orange	Brown or Green

The American Welding Society (AWS), in cooperation with the American Society for Testing Materials (ASTM), has made certain standard classifications of electrodes. The principal electrodes which have application to farm welding are described briefly in the following paragraphs and in Table 16-1. Fortunately, most farm welding can be done with only a very few different types of electrodes.

Electrodes for welding mild steel *AWS No. E6013* electrodes are designed for general-purpose welding of mild-steel parts in all positions (flat, horizontal, vertical, overhead), and are the most commonly used electrodes in farm welding.

AWS No. E6012 electrodes are better for poor fit-up work, and where the edges cannot be properly cleaned of foreign material.

AWS No. E6011 electrodes give deep penetration and are sometimes preferred for vertical and overhead welding, particularly with some a-c farm-type welders which give high open-circuit voltages.

Electrodes for welding cast iron *Nickel-alloy* electrodes are used in making machinable welds in cast iron. They are rather expensive but produce welds that are soft enough to be cut by filing, drilling, sawing, etc. They are also preferred for making welds in engine water jackets and other parts that cannot be preheated. *Steel electrodes for cast iron* are used for welds that do not have to be machinable. Electrodes for welding cast iron do not have AWS numbers.

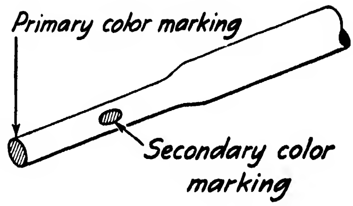
Electrodes for welding high-carbon steel *AWS No. E6016* electrodes are used for welding parts of high-carbon steel, such as automobile and truck bumpers, plowshares, disk-harrow blades, spring-tooth-harrow teeth, and so forth. These work best with d-c welders or with industrial-type a-c welders. *AWS No. E6013* electrodes may often be used for welding high-carbon steel parts if they are preheated.

Electrodes for hard surfacing *Alloy-steel electrodes* are available for hard surfacing parts which are subject to wear. Some produce surfaces which are very hard and wear-resistant, but brittle; and others produce surfaces which are tough and impact-resistant, but not so hard and wear-resistant. Some hard-surfacing materials are also available in powder form for application with the carbon arc torch. Hard-surfacing materials are not standardized, and instructions of the manufacturers are helpful in selecting and applying them.

Electrode size Electrodes of large size can carry larger currents and produce more heat and are used for welding thick material. Small electrodes are used for welding thin material. Most farm welding is done with ⅛-in. and 5/32-in. electrodes.

Electrode markings The National Electrical Manufacturers' Association has adopted certain standard color markings for distinguishing different types of electrodes. Two color spots or bands may be placed on the electrode, one at or on the bare end and known as the primary color marking, and the other on the side, near the end, and known as the secondary color marking (see Fig. 16-5). Not all electrodes have color markings, nor do all those which have color markings have both primary and secondary markings (see Table 16-1). None of the commonly used electrodes for welding mild steel have primary or end color

Fig. 16-5. Types of electrodes are indicated by color markings. The AWS No. E6013 electrode, the most commonly used type for farm welding, has a brown secondary color marking and no primary color marking.



markings. The No. E6013 electrode, the one most commonly used in farm welding, has a brown secondary (side) color marking and no primary color marking. Not all manufacturers conform to the color-marking standards. For example, some electrodes for mild steel have blue tips; some for cast iron have black tips; and some for hard surfacing, green tips.

Quantities of electrodes for the farm shop The most commonly used kinds and sizes of electrodes may be more economically purchased in 25- or 50-lb packages. Less frequently used kinds and sizes should be purchased in 1- to 5-lb lots. The coatings of many electrodes, particularly those for welding cast iron, absorb moisture from the air and deteriorate with time if they are not properly protected and stored. It is therefore usually best not to purchase more than a few months' supply at a time. Assortments of different kinds and sizes of electrodes are available from some manufacturers and from mail-order companies. Table 16-2 may be used as a guide in purchasing electrodes for the farm shop.

TABLE 16-2. Suggested Quantities of Electrodes for the Farm Shop

Kind of electrode	Size, in.	Quantity, lb	Kind of work for which suited
E6013	5/32	25 or 50	General purpose, steel
E6013	1/8	25 or 50	General purpose, steel
E6013	3/32	5	General purpose, steel
E6012	1/8	25 or 50	Poor fit-up work, steel
E6011	1/8	5	Deep penetration, vertical and overhead, steel
Nickel alloy for cast iron	1/8	2	Machinable welds in cast iron
Steel electrodes for cast iron	1/8	5	Nonmachinable welds in cast iron
Hard surfacing	1/8	2	Hard surfacing

Storing electrodes Store electrodes in a dry place and where they will be protected from mechanical injury. Keep them in order in packages or compartments on racks or shelves in such a way that particular kinds and sizes can be quickly identified and selected. A

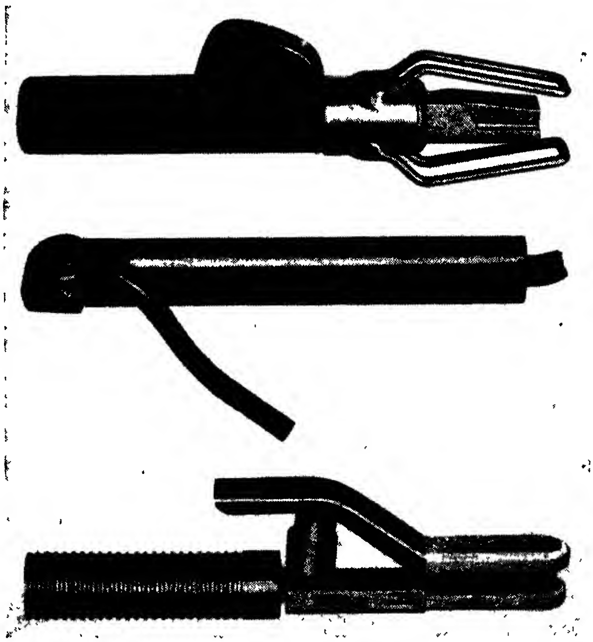


Fig. 16-6. Types of insulated electrode holders. Such holders are usually preferred for farm welding. (James F. Lincoln Arc Welding Foundation)

small container holding an assortment of electrodes which can be moved about from job to job is very convenient.

3. SELECTING ARC-WELDING ACCESSORIES

In addition to the welding machine itself, several other items of equipment will be needed. Most of these, however, are supplied with the welder.

Welding cables Two welding cables are required, one from the welder to the electrode holder, and the other from the machine to the ground clamp. A flexible cable is usually provided for the electrode holder and a semiflexible one for the ground clamp. Having a flexible cable for the ground clamp, as well as for the electrode holder, is usually considered worth the slight extra cost because of the added ease of using and coiling and taking care of the cables.

Electrode holder and ground clamp The electrode holder is connected to the end of the welding cable and holds the electrode. It should

Fig. 16-7. Two types of ground clamps. The ground clamp should be strong and should make a good electrical connection to the work or to the welding table. (James F. Lincoln Arc Welding Foundation)

be light, well balanced and easy to handle, strong, and durable, and should stay cool while in operation. Two general kinds of electrode holders are in use, known as *insulated* and *uninsulated*. The insulated holder has jaws that are completely insulated. While somewhat more costly, such a holder will prevent a flash in case the jaws accidentally come in contact with the work or the welding table, and they afford somewhat better protection against shock hazard, which may be important when welding on damp footing.

The ground clamp is attached to the end of the ground cable and is clamped to the work or the welding table to complete the electric circuit. It should be strong and durable, with a strong spring and contact jaws or surfaces that will give a good, low-resistance connection.

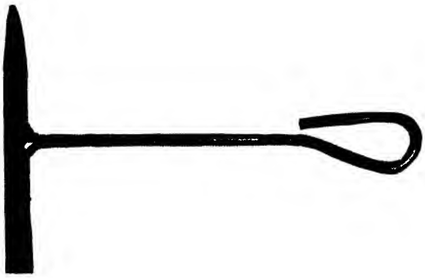


Fig. 16-8. A chipping hammer for removing slag can be easily made in the farm shop.

Chipping hammer and wire brush A chipping hammer is needed for removing slag from welds. A very satisfactory one may be made in the shop (see Fig. 16-8). One end of the head, which is made of tool steel, is sharpened like a cold chisel, and the other end is sharpened to a blunt, round point.

A wire brush is needed for cleaning and preparing work to be welded and also for removing slag from welds, particularly those that are to be overlaid with other beads.

Fig. 16-9. A wire brush is needed for cleaning parts to be welded and to help in removing slag.

Welding table A metal table is needed for arc welding so that parts to be welded may be grounded by simply placing them on the table and connecting the ground clamp to some part of the table. The welding table can be easily made in the shop of steel plate and pipe or angle iron. A top ¼ in. thick is usually satisfactory. The top should be at a comfortable working height, usually about 30 to 34 in.

Face and head shields A face and head shield, of either the hand or the helmet type (see Fig. 16-11), is required to protect the eyes and face from the rays of the arc and from spatter, or flying particles of hot metal. The hand-type shield is more comfortable and convenient

Fig. 16-10. A suitable welding table can be made in the shop.

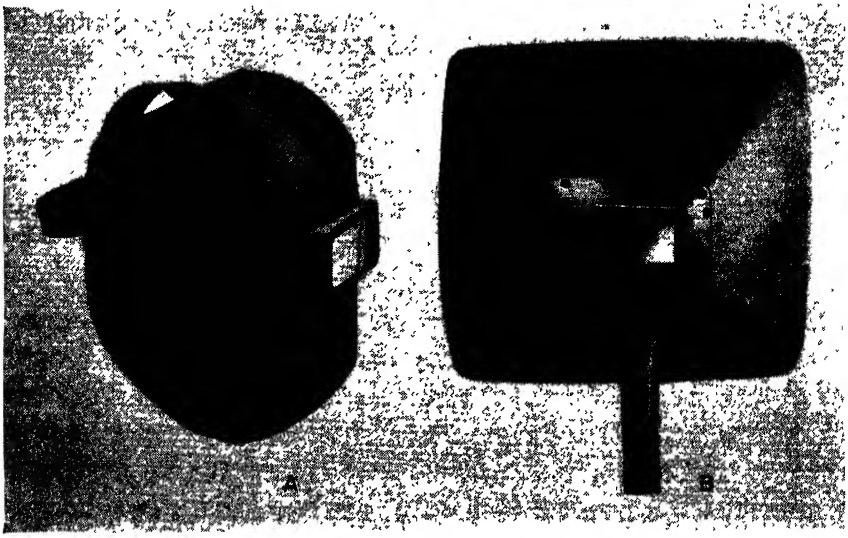


Fig. 16-11. Head and face shields for electric arc welding: *A*, helmet type; *B*, hand type. (James F. Lincoln Arc Welding Foundation)

to use, and is generally preferred for farm welding wherever the work can be done with one hand. The helmet type, while somewhat cumbersome and uncomfortable to wear, leaves both hands free, and is preferred by some.

Shields are made of lightweight, black, nonreflecting fiber, and have a dark glass lens to filter out the harmful rays of the arc. The lenses are graded according to color intensities, common grades ranging from No. 8 to No. 14. Number 10 is usually recommended for farm welding. A clear cover glass is used in front of the dark lens to protect it from spatter. After a cover glass has become badly pitted or fogged, it can be easily replaced. Never use a shield with a cracked colored lens.

Welding screens If others are to be around where welding is done, they should be protected from the rays of the arc by some sort of screen

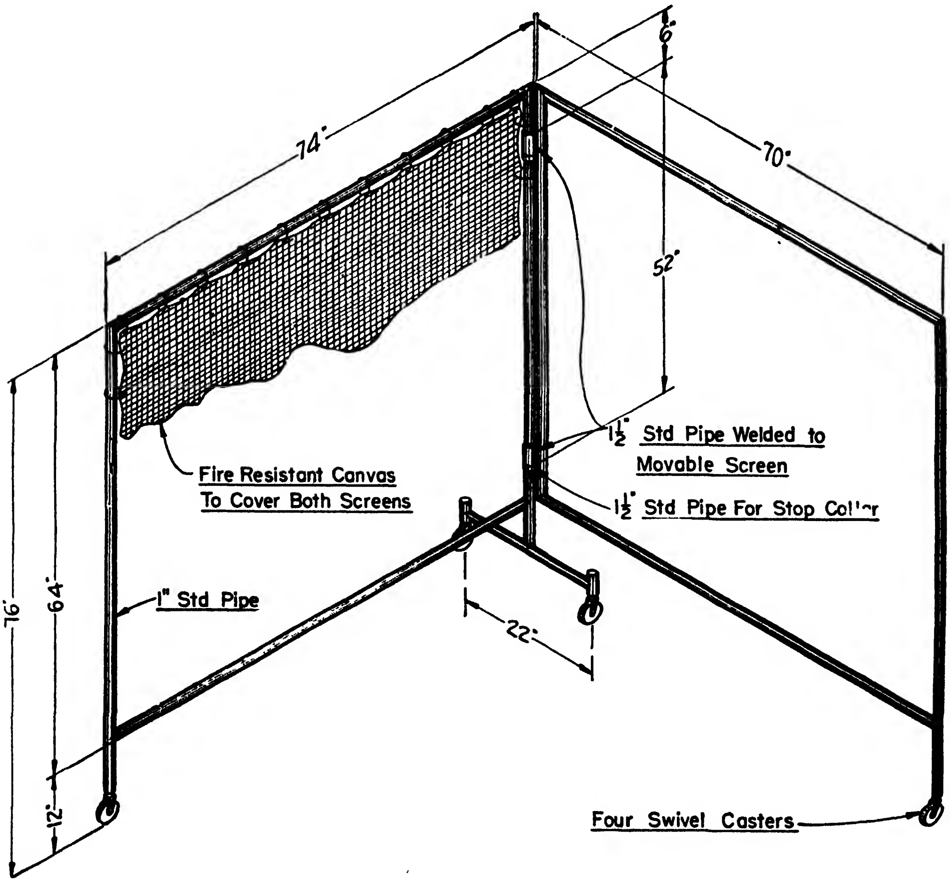


Fig. 16-12. Plan for a portable welding screen. (James F. Lincoln Arc Welding Foundation)

or welding booth. A good portable screen may be made of fire-resistant canvas mounted on a light framework of pipe (see Fig. 16-12).

Carbon arc torch The carbon arc torch is an accessory that can considerably increase the usefulness of an arc welder in the farm shop. It is a very convenient source of heat and is used principally for braze welding, soldering, preheating of parts to be welded, and general heat-

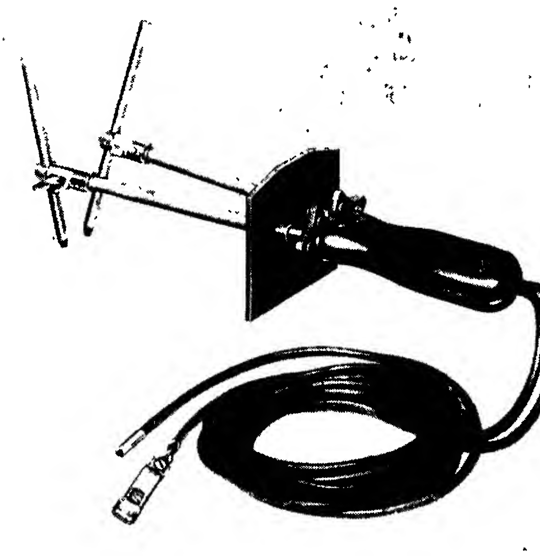


Fig. 16-13. The carbon-arc torch is used for braze welding, preheating, and other general heating work about the shop. (James F. Lincoln Arc Welding Foundation)

ing of parts to be bent, shaped, or straightened. Current passes between the ends of two carbons held in the torch, creating an arc flame of very high temperature which is played upon the parts to be heated.

4. USING SAFETY MEASURES IN ARC WELDING

Welding with the electric arc is a comparatively safe process, although accidents may result from careless or improper use of equipment. Some of the important safety precautions are outlined in the following paragraphs.

Avoiding shock hazards The farm welder is normally supplied with current at 230 volts. It is important, therefore, that the wiring be done

in an approved and safe manner. The output voltage of a limited-input farm-type welder that meets the standards of the National Electric Manufacturers Association does not exceed 65 volts. On some others the maximum open-circuit voltage may be somewhat higher. Voltages of this order can be dangerous, and it is important that the operator stand on dry footing when welding, and that he keep his body insulated from the electrode, any bare parts of the electrode holder, and the work. Be sure to open the main power switch before working on the welder or any of its connections.

Protecting against radiation from the arc The light rays given off by the arc are similar to those from the sun, but much more intense at close range. Therefore, in welding always use a face or head shield that is in good condition, and *never, under any circumstances, look at the arc with the naked eye.* Exposures even for a brief time may cause eye burns that are exceedingly painful, although not permanently injurious. Do not strike an arc or weld when others are about without first being certain that they have protective equipment or will look in the opposite direction.

Treating eye burn In case of eye burn, which feels like "hot sand in the eyes," the following treatment may be used:

Put a drop of 2 percent butyn in each eye and repeat in two hours if necessary. This is to relieve the pain. If butyn is not available, apply sweet oil once an hour until the acute burning sensation disappears. Take aspirin in ordinary doses to relieve pain. Afterward a few drops of 5 percent solution of argyrol may be applied to aid healing, but it should not be used oftener than once in 5 or 6 hours. In severe cases of eye burn see a doctor.

Wearing protective clothing Always wear suitable clothing when welding to give protection both against the rays of the arc and against spatter. Exposure to the arc usually causes a condition similar to sunburn, but often more severe. Therefore, wear a long-sleeved shirt, with collar and sleeves buttoned. Dark clothing is better than light. High-top shoes give better protection against particles of hot metal than low ones, and it is better to wear cuffless pants or pants with the cuffs turned down. Wear gloves, preferably of leather and of the gauntlet type, to protect the hands and wrists.

• **Wearing clear goggles** When chipping slag or grinding protect the eyes from flying particles with goggles.

Providing ventilation Always weld in a well-ventilated place. Fumes given off from welding are unpleasant and in some cases may be injurious, particularly when galvanized or zinc-coated parts are being

Fig. 16-14. Always do welding or cutting in a well-ventilated place. Fumes may be injurious and should not be inhaled. (Note the ventilating fan permanently mounted in the shop window.)

welded. When it is necessary to weld in close quarters, use a fan to give forced ventilation.

Avoiding fire hazards Do not weld around shavings, oil, grease, hay or feed, or other combustible or flammable materials where sparks might cause a fire. Keep the welding booth clean and free of scrap and rubbish.

Never weld or heat drums or other containers which have been used for storing gasoline, oil, or similar materials without first having them thoroughly cleaned. Even a trace of combustible materials remaining in the seams of a container can be vaporized by the heat of welding and cause a serious explosion and fire. Cleaning is done with high-pressure steam or with a strong solution of caustic soda or washing

powder, and is best entrusted to someone who is properly equipped and has had experience in such work. After thorough cleaning, fill the container with water to within a few inches of the point of welding or heating, and keep it filled while the work is being done. Vent the top of the container to allow the escape of heated air.

Summary of safety precautions

1. Never look at the welding arc with the naked eye.
2. Always use a head or face shield that is in good condition.
3. Wear suitable clothing to protect all parts of the body from arc burn and from spatter, as leather gloves, long-sleeved shirts with cuffs and collar buttoned and cuffs on pants turned down.
4. Do not strike an arc or weld until you are sure those in the vicinity have protective equipment or will look in the other direction.
5. Do not weld around combustible or flammable materials.
6. Do not pick up hot metal.
7. Do not weld in confined places without adequate ventilation.
8. Always open the main switch or disconnect the plug when checking over a welder.
9. Do not leave the electrode holder on the welding table or in contact with a grounded metal surface.
10. Do not use worn or frayed cables.
11. Stand on dry footing when welding, and keep the body insulated from the electrode, the electrode holder, and the work.
12. Keep the shop clean, particularly around the welder.

5. STRIKING AN ARC AND RUNNING A BEAD

Making preliminary adjustments Before starting to weld, select an electrode of suitable kind and size for the work to be done, and make a preliminary setting of the welding current (see Table 16-3, page 495). After a little experience, an operator soon learns the best current setting to use.

Fasten the ground clamp securely to the work or the welding table, and get the helmet-type shield adjusted or the hand-type shield in readiness.

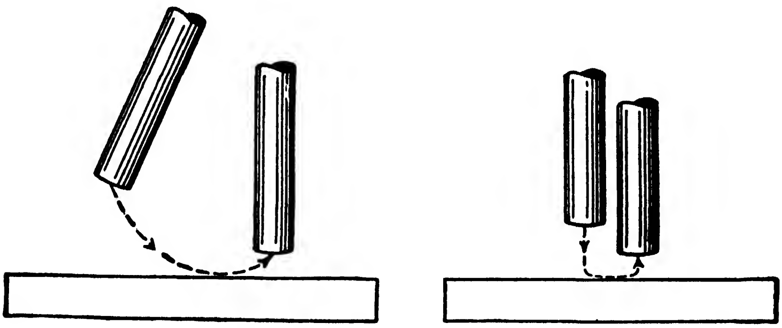
Striking the arc Two methods are commonly used for starting or striking the arc, the scratching method and the tapping method. With

TABLE 16-3. Approximate Current Setting for Welding Steel of Different Thickness and with Electrodes of Different Sizes

Electrode size	Metal thickness, in.					
	1/32	1/16	1/8	3/16	1/4	5/16 up
5/64	20	30				
3/32	20	30	65			
1/8			80	105	130	140
5/32			90	140	150	170
3/16				150	170	180

either method the coating on the electrode tip should first be knocked off.

By the scratching method To start the arc by the scratching method, simply move the end of the electrode down onto the work with a slow sweeping motion, similar to striking a match. When the



A B

Fig. 16-15. Two methods of striking an arc: *A, the scratching method*—move the electrode downward with a sweeping motion; when the end touches the metal, continue a little further, raising the electrode slightly. *B, the tapping method*—lower the electrode slowly, tapping it or bouncing it lightly on the work.

electrode touches the metal, continue the sweeping motion a little further, raising the electrode slightly (see Fig. 16-15*A*).

By the tapping method To strike an arc by the tapping method, keep the electrode perpendicular to the work, lowering it slowly and tapping or bouncing it lightly on the work (see Fig. 16-15*B*). This method is preferred by some for quickly restarting an arc that is momentarily broken while welding.

If the electrode sticks to the work, quickly bend it back and forth, pulling at the same time. Be sure to keep the shield in front of the face to protect against the flash when the electrode breaks loose. In case this does not free the electrode, release it from the holder. This will damage the holder somewhat and should be avoided if possible. Do not open the switch on the welder when an electrode sticks, because the resulting arcing would damage the switch contacts. In case of repeated sticking of the electrode, use a somewhat higher current setting.

Once the arc is struck, move the electrode along slowly from left to right, assuming you are right-handed. Lean the top of the electrode about 15 to 25 deg in the direction of welding. This gives a better view of the arc, and also keeps more of the molten metal back out of the crater and gives better penetration.

To break the arc at the end of the bead, hold the electrode still long enough to fill the crater and then gradually lift it straight up from the work.

Do not grip the electrode holder too tightly, as a tight grip produces fatigue and makes it difficult to control the movement of the electrode.

Holding the proper arc length The length of arc greatly affects the strength, smoothness, and uniformity of the weld. The best length of arc varies somewhat with different kinds of electrodes but is usually about equal to the diameter of the electrode with the coating removed. (The arc length is the distance from the tip of the core of the electrode to the bottom of the crater.) As the end of the electrode melts off, it must of course be continually lowered to maintain the same length of arc.

In general, use a short arc, but not so short that the coating on the electrode touches the molten metal on the work, as this would cause a porous weld. The proper length of arc may be judged by (1) the appearance of the arc, (2) the appearance of the weld produced, and (3) the sound of the arc. Experience will enable an operator to know quickly when he is using an arc of correct length.

A short arc gives a steady flame that surrounds and protects both the work and the molten metal as it passes from the end of the electrode (see Fig. 16-16). A long arc, on the other hand, gives a flame that whips about and exposes the molten metal passing from the electrode and also the molten metal on the work (see Fig. 16-17). The hot metal,

being unprotected from the atmosphere, burns and oxidizes somewhat and becomes porous, resulting in a rough, weak weld.

A short arc gives good penetration, with little or no overlap of deposited metal. Also, there will be a minimum of spatter. A long arc gives a wide shallow bead with considerable spatter. The deposited bead will also be rough and uneven instead of smooth and uniform.

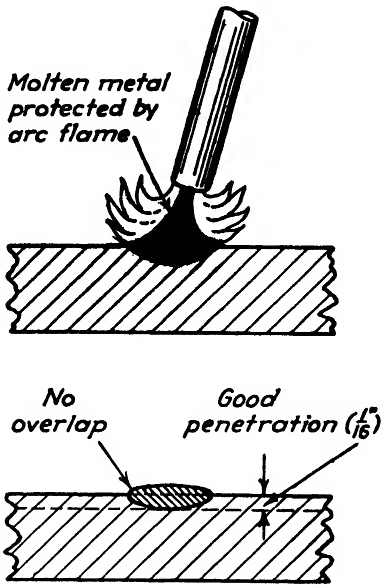


Fig. 16-16. Weld with a short arc. This protects the metal being deposited, and gives good penetration with little or no overlap.

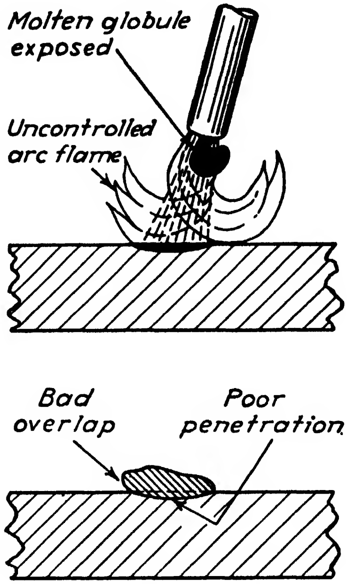


Fig. 16-17. A long arc gives a flame that whips about and gives insufficient protection for the metal being deposited. The penetration is poor and the overlap is bad.

The length of arc may also be judged by its sound. A short arc, with proper adjustment of the welding current, will give a sharp crackling or "frying" sound. A long arc makes more of an interrupted humming or sputtering sound.

Restarting a bead If possible, make a bead in one continuous operation. If for any reason a weld is stopped, chip the slag away from the crater and the end of the bead before continuing with the weld. After removing the slag, strike the arc ahead of the crater and then move it back through the crater and fill it before proceeding again in the forward direction (see Fig. 16-18). In this way the new portion of the bead will be thoroughly fused and joined with the old portion.

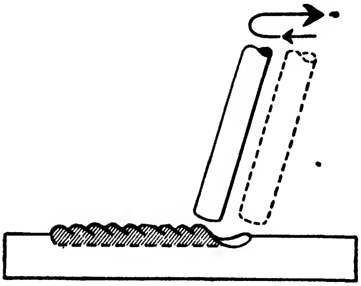


Fig. 16-18. To restart a bead, strike an arc ahead of the crater, move back through it, and then resume welding in the forward direction.

Adjusting the welding current The current setting greatly affects the penetration and the strength of the weld. Too low a current gives shallow penetration and a high bead that is not well fused into the base metal (see Fig. 16-19*B*). There will be considerable overlap and welding will be slow. The arc will also be hard to maintain and control. Too high a current penetrates too deeply, makes too wide a crater, with

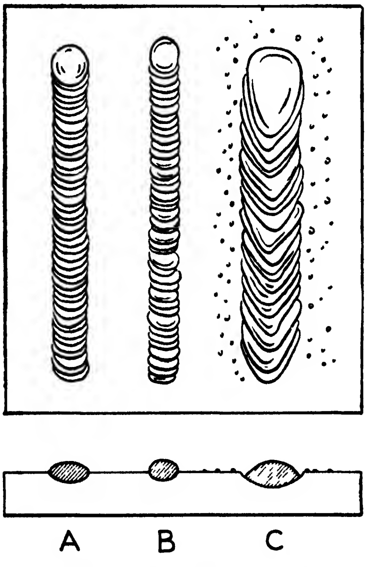


Fig. 16-19. Effects of current setting on the weld: A, proper adjustment of the current, giving fairly deep penetration, with good fusion and no overlap or undercutting. *B*, current too low, resulting in a high bead with poor penetration and poor fusion. C, current too high, resulting in deep penetration, undercutting at the edges of the bead, and excessive spatter. Note also the long crater at the end of the bead.

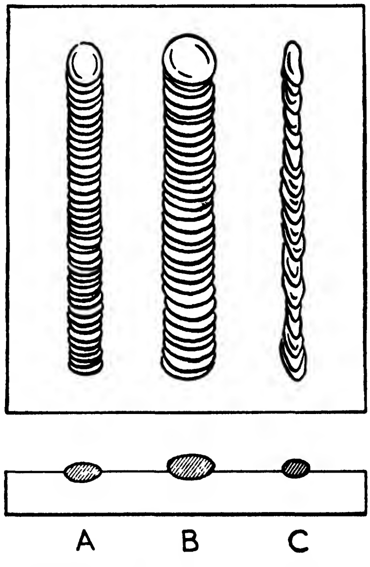


Fig. 16-20. Effects of speed of electrode movement on the weld: A, proper speed, giving a normal bead with good penetration and fusion, *B*, movement too slow, resulting in a large, wide bead with overlap. C, movement too fast, resulting in a small, narrow, irregular bead with poor penetration. Note that the ripples are elongated.

undercutting at the edges, and tends to produce excessive spatter (see Fig. 16-19*C*).

Gaging the speed of electrode movement The correct speed of movement of the electrode depends upon the size of electrode, the current adjustment, and the thickness of the metal being welded. Moving the electrode too slow builds the metal up too high, with resulting wide bead and overlap. Moving it too fast gives an irregular, flat, low bead of poor penetration (see Fig. 16-20). Move the electrode just fast enough to keep the arc at the forward edge of the crater and maintain a crater from 1 to 1½ times the diameter of the electrode. In running a straight bead with a little side weaving, an electrode should produce a bead about equal in length to the electrode consumed.

Weaving the arc Although a steady, uniform movement will produce a satisfactory bead for many purposes, a slight weaving or oscillat-

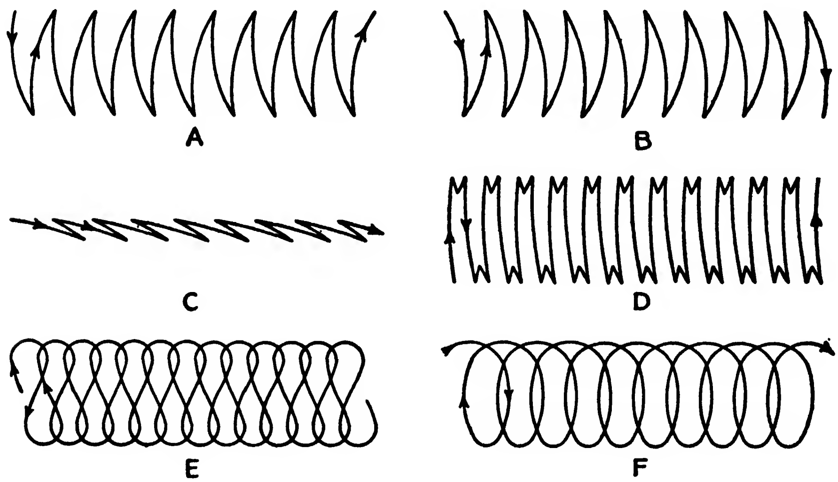


Fig. 16-21. Common patterns for weaving the electrode. *A* and *B*, two types of crescent weave; C, back-and-forth weave with only a little side motion, used for making narrow beads; *D*, a pattern for giving slight hesitation at the edges of the bead; *E*, a figure-8 weave; *F*, a circular weave.

ing motion is preferred for most welds. Some gas and slag are usually present in the molten metal of an arc weld. Weaving or oscillating the electrode keeps the metal molten a little longer and allows the gas to escape and the slag to come to the surface, and thus avoids porosity

in the weld. Weaving is also done to produce a wider bead than would be possible without weaving, and sometimes also to give better penetration or better building up of the bead along the edges.

Different patterns of weaving are used by different operators. Some of the more common ones are illustrated in Fig. 16-21. The crescent weaves (Fig. 16-21*A* and *B*) are perhaps most commonly used. They are also among the easiest to learn. For weaving a narrow bead, use a motion that is mostly forward and backward and with very little side motion (see Fig. 16-21*C*). The pattern shown in Fig. 16-21*D* is used to give a slight hesitation at the edges of the bead in order to build up the weld better along the edges.

Making practice beads Before attempting to weld two pieces together, practice running beads on flat steel, keeping in mind the principles discussed in the preceding pages, until you have acquired a fair

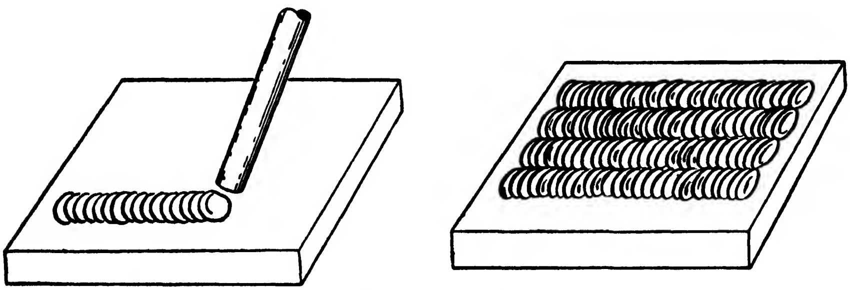


Fig. 16-22. Making practice beads. Time and study spent in acquiring skill in running beads makes for rapid progress in learning to make types of welds used on farm equipment.

degree of skill. To make a good bead, use a suitable current adjustment, length of arc, electrode position, and speed of electrode movement. Depositing beads is a fundamental welding operation, and time and study spent in mastering it will make for rapid and satisfactory progress in learning to make good welds of the types used in the repair and construction of farm equipment.

6. MAKING BUTT WELDS IN THE FLAT POSITION

The butt joint (see Fig. 16-23) is one of the joints most commonly used in farm welding. The parts are lined up in the same plane with their edges almost touching and then welded together. Other common

kinds of joints are ***lap, tee, corner,*** and ***edge*** joints, which are also illustrated in Fig. 16-23. Welds in general may also be classified as *bead, groove,* and *fillet* welds. A bead weld is a deposit of weld metal made on the surface by a single pass of the electrode, as in "building up" or in making a plain butt joint. A groove weld consists of one or more beads deposited in a groove. When more than one bead is used, the weld is called a *multiple-pass* weld (Fig. 16-29), a single-bead weld being called a *single-pass weld.* A fillet weld consists of one or more beads deposited in the angle or corner between two surfaces, as in a tee, lap, or corner joint (Fig. 16-23*C, D,* and *E*).

Welding positions Welding on top of a surface that is level or nearly so is known as welding in the *flat position.* Making a horizontal weld on a vertical surface is known as welding in the *horizontal position.* Running a weld vertically up or down on a vertical surface is called welding in the *vertical position.* Welding on the underside of a horizontal surface is called welding in the *overhead position* (see Fig. 16-24).

It is easiest to weld in the flat position, because in this position gravity helps pull the molten metal into the joint. Where possible, therefore, place parts to be welded so that the welding may be done in the flat position. In much farm welding, however, parts have to be welded in place on machines, and welding in other than the flat position is frequently necessary. Even though welding in these other positions is somewhat more difficult, an operator who can do good welding in the flat position can soon learn to do acceptable work in the other positions also. A little study of principles and patient, thoughtful practice are all that is required.

Preparing work for welding Clean the work thoroughly of rust, scale, or other foreign material before welding. Thin parts (1/8 in. thick and under) may generally be placed together and welded without beveling the edges, but thicker parts should be beveled or veed out to insure adequate penetration and fusion of all parts of the weld. On all but thin metal, separate the parts slightly (about 1/16 in.) to allow better penetration of the weld. Where possible on parts more than 3/8 in. thick, make V grooves on both sides.

Usually time spent in veeing out joints and fitting them properly together is time well spent. Careful preparation of the work makes for

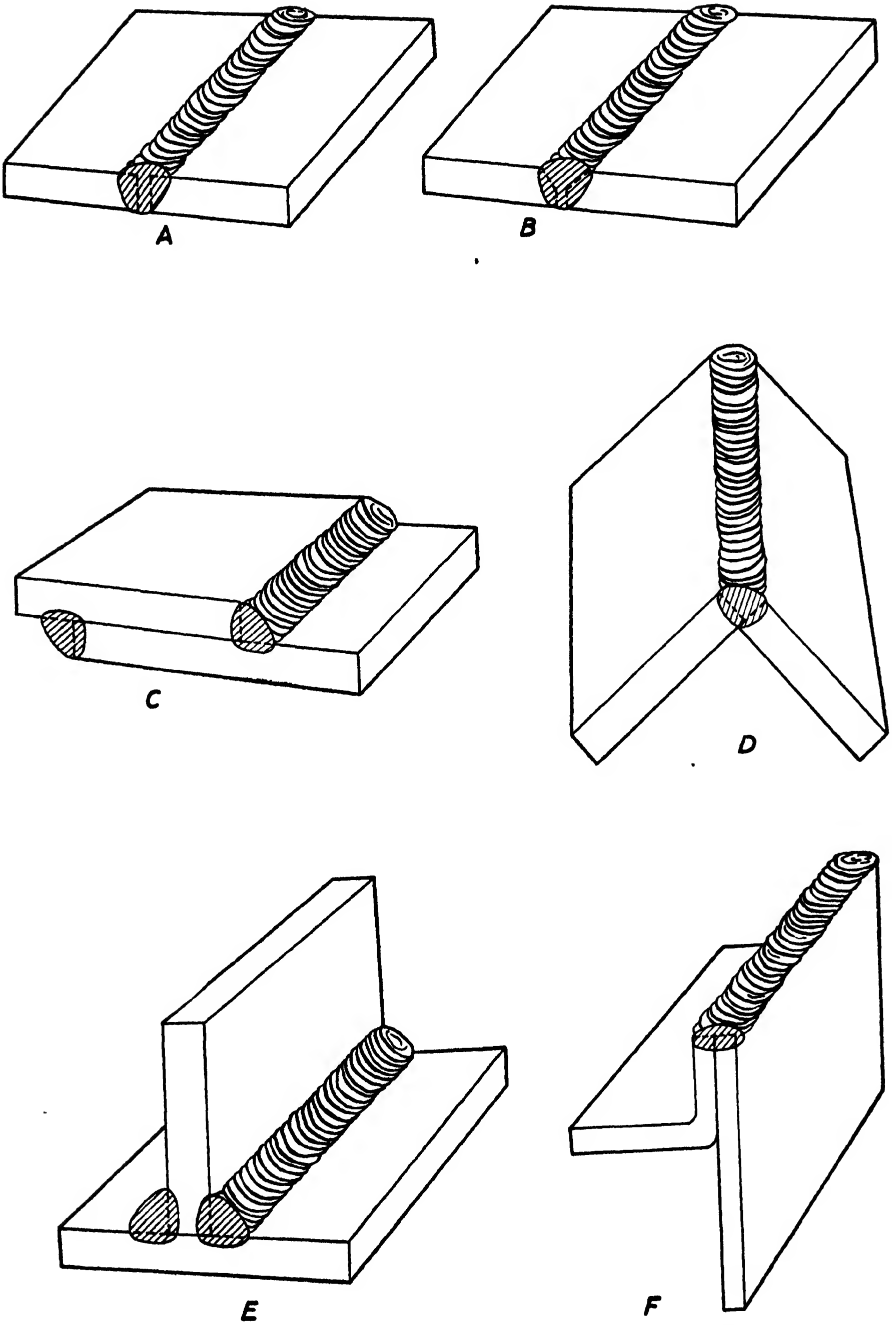


Fig. 16-23. Common types of welded joints: *A*, plain butt joint; *B*, grooved butt joint; *C*, lap joint; *D*, tee joint; *E*, corner joint; *F*, edge joint. Welds on joints C, *D*, *E* are known as fillet welds.

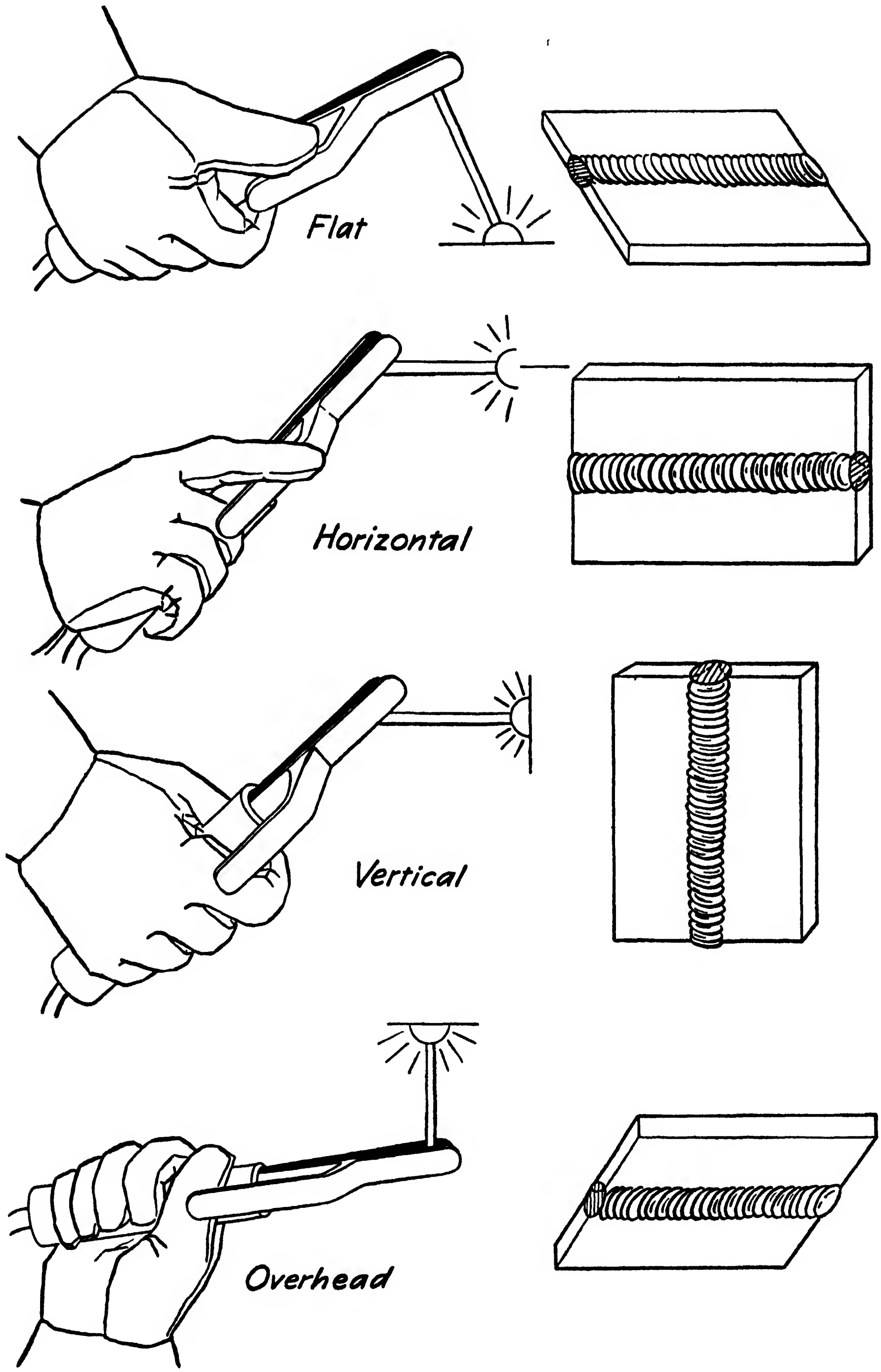


Fig. 16-24. The different welding positions. Welding in various positions is frequently required in farm welding.

stronger welds, as well as for faster welding, better appearance, and lower consumption of electrodes.

Making butt welds in thin steel To butt-weld steel less than ⅛ in. in thickness, place the pieces together without beveling the edges, spacing them apart about one-half their thickness. Select an electrode of suitable size and make a trial setting of the welding current in accordance with the thickness of the material (see Table 16-3). Since thin metal requires careful adjustment of the welding current to prevent burning through, it may be necessary to experiment a little, adjusting the current up or down as required. Parts that fit together poorly require a lower welding current than those which fit well.

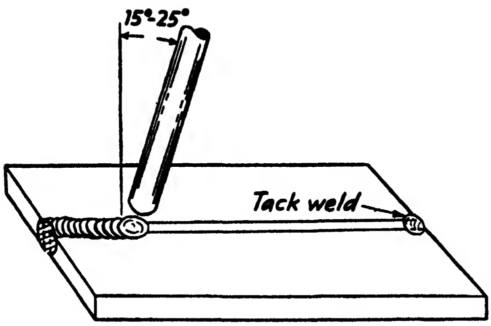


Fig. 16-25. Butt welding thin steel. Beveling of the edges is not required on parts less than about ⅛ in. thick. Space the edges apart a distance equal to about half the thickness of the metal.

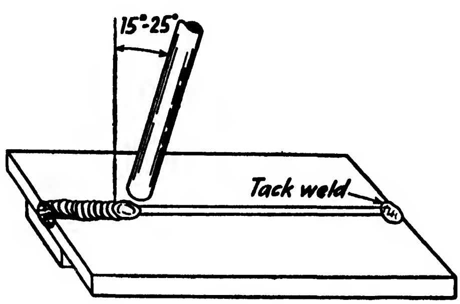


Fig. 16-26. A backing strip is helpful in welding very thin metal and in cases of poor fit-up.

Strike an arc and tack-weld the pieces at intervals to hold them while welding. Remove the slag from the tack welds, and then start welding at one end of the joint (the left end for a right-handed workman), leaning the electrode about 15 to 25 deg in the direction of welding, and moving it along at a steady speed which will give a well-fused uniform bead. The speed of movement and the welding current must be carefully adjusted to produce a good weld without burning through. In case the arc does burn through, do not attempt to fill the hole immediately, but let it cool first, and then reduce the welding current and fill the hole with a weaving motion.

In very thin pieces where there is danger of burning through, and in cases of poor fit-up, place a backing strip under the joint (see Fig. 16-26). Use a steel backing strip when it can be left in place and made a part of the weld for added strength. In cases where a backing

strip cannot be left in place, use one of copper, which will not stick to the weld metal.

Making grooved joint welds Where possible, space the parts about $\frac{1}{16}$ to $\frac{1}{8}$ in. apart in order to get good penetration to the bottom of the groove. Select an electrode of suitable size and make a trial setting of the current in accordance with the thickness of the metal (see Table 16-3). If necessary to hold the parts, tack-weld them at intervals. After

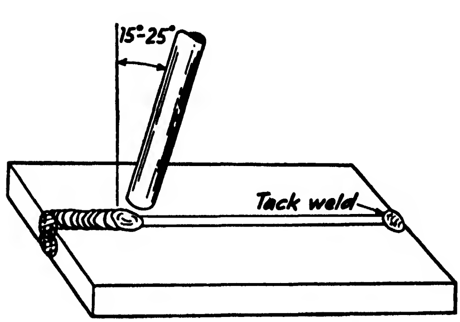


Fig. 16-27. Where it is possible to weld from both sides, butt welds in metal up to $\frac{1}{4}$ in. in thickness may be made without beveling the edges.

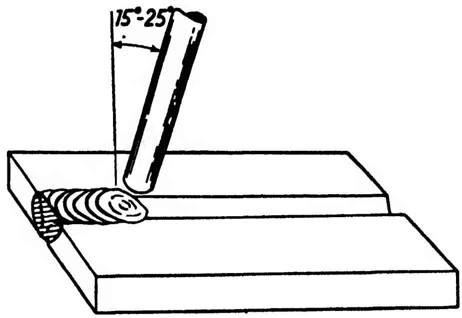


Fig. 16-28. Parts more than about $\frac{1}{8}$ in. in thickness which must be welded from one side should have their edges beveled.

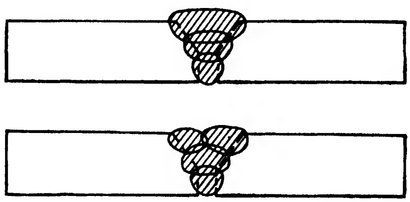


Fig. 16-29. Two methods of depositing beads in multiple-pass groove welds.

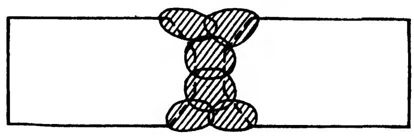


Fig. 16-30. Bevel both sides of parts thicker than about $\frac{3}{8}$ in. where it is possible to weld from both sides.

the tack welds cool, chip away the slag, and then strike an arc at the left end of the groove (for a right-handed workman) and lay a bead in the bottom of the groove. Lean the electrode about 15 to 25 deg in the direction of welding (see Fig. 16-28). Use a short arc, but do not allow the coating of the electrode to drag on the bottom or sides of the groove. Do not weave the arc, but run a straight bead.

In thick pieces which require more than one pass with the electrode, thoroughly remove the slag by chipping and brushing, and then deposit additional beads as required (see Fig. 16-29). Use a crescent

weaving motion after the first bead, hesitating slightly at the sides of the groove to insure good fusion. If the work is veed out from both sides, weld a bead on one side and then one on the other side in order to distribute the heating and avoid warping. Finish the weld with the fewest possible number of beads or passes, but avoid excessively wide beads. In general, keep the width of bead under 2½ times the diameter of the electrode.

Welding round rods and shafts To make a butt weld in a round rod or shaft, vee it out to a 60-deg angle on two opposite sides, and place the parts in position with space of ¹⁄₁₆ to ⅛ in. between them (see Fig. 16-31). Straight rods and shafts may be easily held in place in an angle iron. Weld a straight bead in the bottom of the groove on one side, and then turn the rod over and weld one on the other side. Deposit additional beads, alternating from one side to the other to

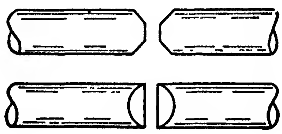


Fig. 16-31. A round shaft prepared for butt welding.

avoid warping. If the weld gets red hot, wait until it cools to a black heat before making another pass.

Where conditions will permit, build the shaft up somewhat oversize at the joint for added strength. Where this cannot be done and an extra-strong weld is needed, it may be advisable to relieve the stresses caused by the alternate heating and cooling during welding. This may be done in either of two ways. One is to anneal the weld by heating it to a red heat and then allowing it to cool slowly. If possible, cover it with asbestos paper, dry lime, or ashes while cooling. The other way to relieve the stresses is to heat the joint to a red heat (in a forge if one is available) and then hammer it on an anvil with a heavy hammer.

7. MAKING FILLET WELDS IN FLAT AND HORIZONTAL POSITIONS

A fillet weld consists of one or more beads run in the angle or corner between two surfaces, as in a tee, lap, or corner joint (see Fig. 16-23). A fillet weld should penetrate well into both pieces being

joined, and should extend out on each surface to a distance about equal to the thickness of the pieces. For most work a weld that has a flat or slightly convex surface is preferred. To insure a good strong weld, it is important to hold the electrode at a suitable angle, and to use a suitable current setting and speed of electrode movement.

In making a fillet weld between two plates of the same thickness, hold the electrode so that it bisects the angle between them, and lean

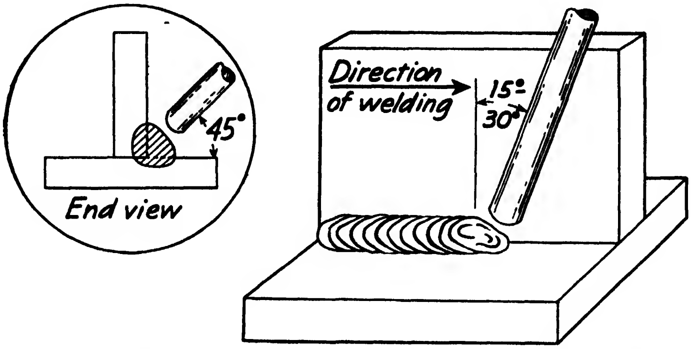
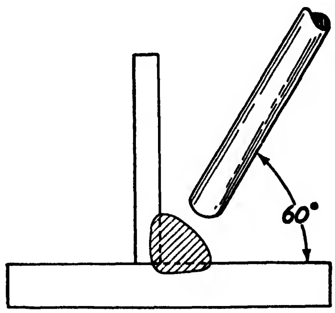


Fig. 16-32. Making a fillet weld between two pieces of equal thickness. The electrode should about bisect the angle between the two pieces, and the top should lean about 15 to 30 deg in the direction of welding.

Fig. 16-33. In making a fillet weld between parts of unequal thickness, point the electrode more toward the thick part to give uniform heating and penetration.



the top about 15 to 30 deg in the direction of welding (see Fig. 16-32). In welding parts of unequal thickness, point the electrode more toward the thick piece, in order to give uniform heating and penetration in both pieces (see Fig. 16-33).

Use a short arc in making fillet welds, as this gives better penetration down into the corner between the two parts. Watch the crater closely and make sure that you get good penetration. Speed of electrode movement is quite important. If it is too fast, there will be poor penetration and undercutting; if too slow, the metal will pile up and give bad overlap.

Electrode sizes and approximate current settings for fillet welds in steel of different thicknesses may be taken from Table 16-3.

Welding a tee joint To weld a tee joint, strike an arc at the left end (for a right-handed workman) and hold it until the crater penetrates well into the corner between the two pieces. Then move the electrode along slowly without weaving, watching the crater and making sure of good penetration. If the metal is thicker than ¼ in., additional passes will usually be required to build the weld to suitable size, and these may be made with straight beads or with a weaving motion. The second bead should be placed on the lower or horizontal surface, so that it can serve as a sort of shelf upon which to build the next bead (see Fig. 16-34).

Making lap welds To lap-weld two pieces together, simply lap them over each other a suitable distance and hold them in place while fillet welds are made at the ends of the laps. These welds are made

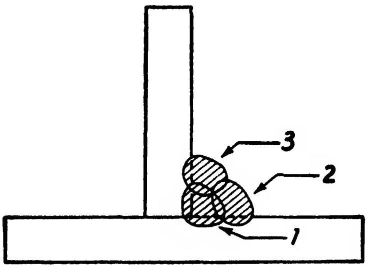


Fig. 16-34. In multiple-pass fillet welds in flat and horizontal positions, place the second bead on the horizontal surface to form a support for the third one.

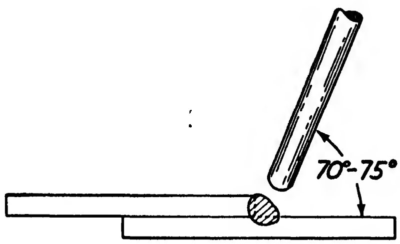


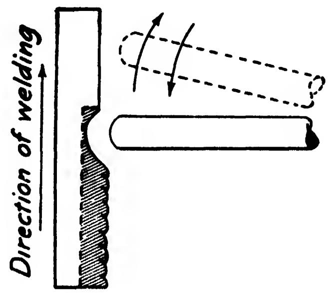
Fig. 16-35. In making a lap weld in thin material (up to about 1/4 in. thick), point the electrode more toward the flat piece to better control the heat and the placing of the weld metal.

in the same manner as fillet welds in a tee joint, except in the case of thin metal (up to ¼ in. in thickness). Such a weld is usually made in one pass, and with the electrode pointed more toward the flat piece (see Fig. 16-35), in order to better control the distribution of heat and the placing of the metal. A crescent or circular weave with slight hesitations at the edges of the bead is used to give better fusion and better shape to the weld. For added strength or stiffness, the edges of the lapped joint may be welded, using a single pass with a weaving motion.

8. WELDING IN VERTICAL, HORIZONTAL, AND OVERHEAD POSITIONS

The main difference between welding in these positions and in the flat position is that gravity tends to pull the molten metal out of the weld instead of helping to hold it in. It is therefore necessary for the operator to keep the puddle of molten metal under control and not let it get too large and run down. This is done by means of special techniques, such as using lower current settings, smaller electrodes, or special electrodes, carefully controlling the speed of movement of the electrode, and using weaving motions to control the application of heat to the various parts of the weld. In welding a bead up on a vertical

Fig. 16-36. To deposit a narrow bead in welding up, give the electrode a short, quick upward whipping motion, using a wrist action.



surface, for example, a short whipping motion is given to the end of the electrode by means of wrist action. The tip of the electrode is moved up out of the crater for an instant to let the metal cool a little and then brought back down quickly to deposit more metal. In this way the molten metal is kept from getting too hot and running down.

Some of the more important practices for welding in horizontal, vertical, and overhead positions are as follows:

1. Use a short arc.
2. Use a somewhat lower current setting than for flat-position welding.
3. Carefully control the speed of electrode movement. Moving too fast will give irregular, poorly fused welds. Moving too slow will cause the metal to pile up and then run down out of the puddle. Proper speed gives good penetration and a good shape of bead.
4. Use electrodes suited to horizontal-, vertical-, or overhead-position welding. AWS No. E6011 electrodes are preferred by some operators over No. E6013, the type commonly used for general-purpose weld-

ing of steel with a-c farm welders. It is difficult to maintain the arc, however, when No. E6011 electrodes are used with welders which have low open-circuit voltages.

5. Use a suitable electrode position to control the placing of the weld metal. Use special weaving motions where they will be helpful.

Making vertical-position welds in steel Vertical welds are usually made from the bottom up, except in thin material—3/16 in. in thickness and under—in which welds are usually made from the top down, because there is less danger of burning through when welding down.

Welding upward Use a somewhat lower current setting than when making similar welds in the flat position. Strike an arc, and when the

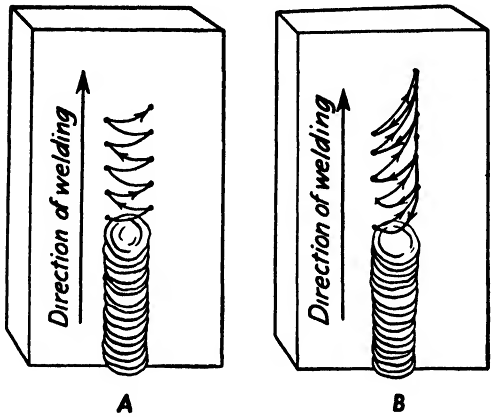


Fig. 16-37. To make a wide bead in welding up, use a semicircular or crescent weave, as at *A*, or a J weave, as at *B*.

crater is a little larger than the diameter of the electrode, move it up at a steady speed which will give a good penetration and a uniform bead. Keep the electrode about perpendicular to the surface and hold a short arc.

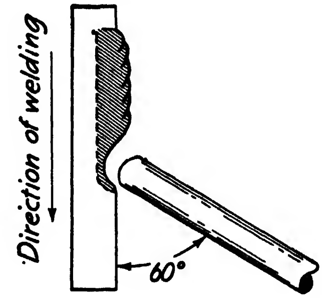
To make a wide bead, use a semicircular or crescent weave with the electrode going up at the edges, or a "J" weave with the electrode going higher on the right edge than on the left (see Fig. 16-37). With the "J" weave the arc goes up and to the side of the crater momentarily, allowing a right-handed operator to see into the crater better, and thus better watch and control his weld. (A left-handed operator would use a reversed "J" weave.)

Welding downward In welding beads down, point the electrode up at an angle of about 60 deg and use a slightly higher current setting and a faster speed of welding than when welding up. Pointing the arc upward helps to hold the molten metal back up out of the crater, and

thus gives better penetration. It also forces the slag back and keeps it from running down and being trapped in the weld. For depositing wide beads use a weaving motion.

In making butt welds and fillet welds in vertical position, use methods similar to those for corresponding welds in flat position, but with

Fig. 16-38. In welding down (done principally on thin metal), point the electrode up at an angle of about 60 deg. Use a slightly higher current setting and a faster speed than when welding up.



changes in current setting, position of electrode, and speed of welding as may be required to control the puddle and get good penetration and uniform beads.

Making horizontal position welds in steel In welding in the horizontal position, hold the electrode in a horizontal plane, but lean it about 15 deg in the direction of welding. Use a somewhat lower

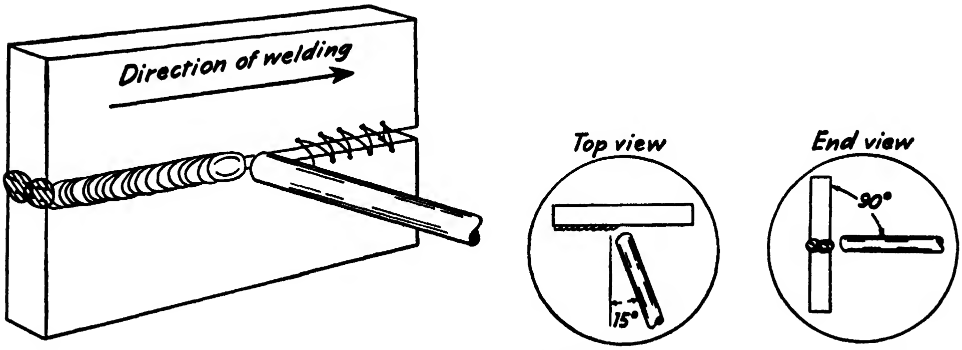


Fig. 16-39. In horizontal position welding, hold the electrode horizontal but lean the top about 15 deg in the direction of welding.

current setting than for welding in the flat position, hold a short arc, and use a weaving motion to help keep the molten metal from running down (see Fig. 16-39). Note that the weave curves or arches upward rather than downward. This deposits the metal somewhat higher in

the weld, and thus better counteracts the tendency of molten metal to sag downward from the bead. For making wide beads, a circular weave may be used.

Making horizontal grooved butt welds In order to secure good penetration in butt welds in material over ¼ inch thick, it is necessary to vee them. Such welds in horizontal position usually require more than one pass. Deposit the first bead with the electrode pointing straight in, but leaning slightly in the direction of welding. Deposit the second bead on the lower piece with the electrode pointing downward at about 60 deg, and the third one with the electrode pointing up (see Fig.

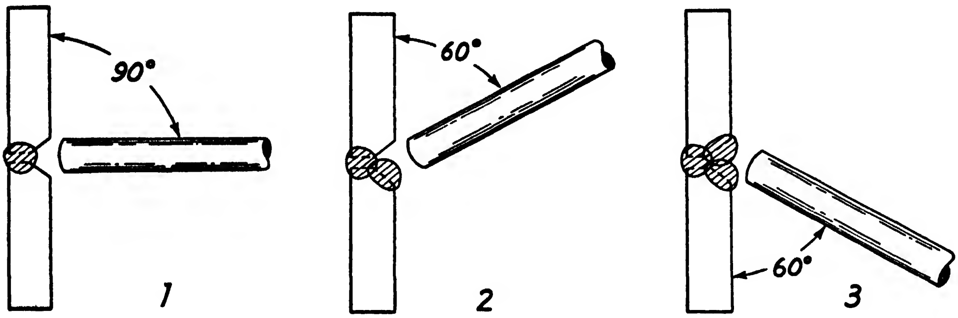


Fig. 16-40. Steps in making a multiple-pass grooved weld in horizontal position.

16-40). The second bead thus serves as a sort of shelf upon which the third is easily deposited.

Making overhead welds in steel Welding in the overhead position is more difficult than in other positions, because of the action of gravity tending to pull the molten metal down. The operator must therefore plan his work so as to keep the puddle of molten metal small and under control. Most overhead welding is done with small electrodes, usually not over ⅛ in., and with very short arcs. Straight beads are used for most jobs because weaving makes a larger puddle of molten metal, adding to the difficulty of control. Speed of movement of the electrode is impcrtant. Too fast a movement will give poor fusion and an irregular bead, while too slow a movement will cause molten metal to run down and form drops. AWS No. E6011 electrodes are usually preferred to No. E6013 for overhead welding, except on welders which have rather low open-circuit voltages. With such welders it is more difficult to maintain an arc with the No. E6011 electrodes.

9. ARC WELDING CAST IRON

Many cracked and broken castings on farm machinery and equipment can be readily and satisfactorily repaired by arc welding. Welding of cast iron, while not particularly difficult, requires procedures somewhat different from those used with steel. When iron or steel is heated, it expands; when it cools, it contracts. Cast iron is weaker in tension than steel, and cannot withstand stretching forces so well. In welding cast iron, therefore, care must be taken to avoid too rapid heating and cooling, which would set up stresses that might cause cracking. Also, too rapid cooling makes cast iron very hard and brittle.

Preheating To avoid troubles due to too rapid or uneven heating and cooling, castings are often preheated to a dull red, welded while hot, and then cooled slowly after welding. The method of preheating depends upon the size of the casting and the facilities for heating it. Small parts may be preheated with an arc torch, an oxyacetylene torch, a forge, or possibly a gasoline blow torch. Large castings are sometimes heated in a temporary furnace laid up of fire bricks with an opening in one side for applying heat with a large kerosene-burning torch. By means of special methods, however, many castings, particularly small ones, can be welded without preheating.

Preparing welds In preparing a casting for welding, clean it of grease, dirt, paint, rust, etc., and then vee it out if at all possible by grinding or by chipping with a diamond-point cold chisel. A portable grinder is valuable for veeing castings in place on machines. Broken parts must be held in postion by clamping, tack welding, or other means. Where possible, place the parts so that the welding may be done in the flat position.

Welding a casting Electrodes ⅛ in. in size are commonly used for welding cast iron. Use a steel electrode designed for welding cast iron if the weld will not need to be sawed, drilled, filed, or tapped. Set the current somewhat lower than for the same thickness of steel. Hold a short arc, and strive for good fusion but without deep penetration. Too deep penetration results in a large weld with higher temperatures, and more danger of cracking upon cooling.

One good method of avoiding overheating, with its increased danger

of cracking, is as follows: Deposit a short bead of, say, 1 to 2 in. in length. Stop and peen it lightly. When it is cool enough to touch, deposit another short length and peen it in the same manner, and so on until the weld is completed.

In cases where a machinable weld is required, or when joining steel to cast iron, use a nickel alloy electrode. Be careful not to overheat metal deposited from a nickel alloy electrode, as overheating tends to burn the alloy, resulting in a porous weld.

Annealing a welded casting After the weld is completed, bury the casting in dry lime or ashes and allow it to cool slowly, so as to avoid cracking. If the casting cannot be buried, wrap it in asbestos paper.

10. ARC WELDING HIGH-CARBON STEEL

Welds in parts made of high-carbon steel, such as car bumpers, plowshares, and spring-tooth harrow teeth, can be made by using special procedures. These are necessary because high-carbon steel, when cooled rapidly, becomes hard and brittle and may crack.

Welding of high-carbon-steel parts is done much like welding of cast iron. The parts should first be preheated to a blue or dull-red heat, welded while hot, and then slowly cooled. Small parts may be buried in dry lime or ashes, while larger parts may be wrapped in asbestos paper. AWS No. E6013 electrodes are commonly used, but with somewhat lower current settings than for mild-steel welding. Where d-c welders or industrial-type a-c welders are used, special electrodes (AWS No. E6016) are available for welding high-carbon-steel parts.

11. BUILDING UP WORN PARTS; HARD SURFACING

Many worn farm machine parts, such as wheel axles, drawbars, clevises, and mower cutter-bar shoe soles, can be built up by arc welding, and many parts can be hard-surfaced with wear-resisting material to reduce wear.

Building up worn shafts On round shafts and axles, lay the beads lengthwise, the first one on one side of the shaft, and the second one on the opposite side. Then place the third bead halfway between the

first and second, and the fourth opposite the third (see Fig. 16-41). Additional beads are placed in the same order, the fifth being beside the first, and so on. This method avoids overheating and warping. After the part has been built up to required size, it may be smoothed

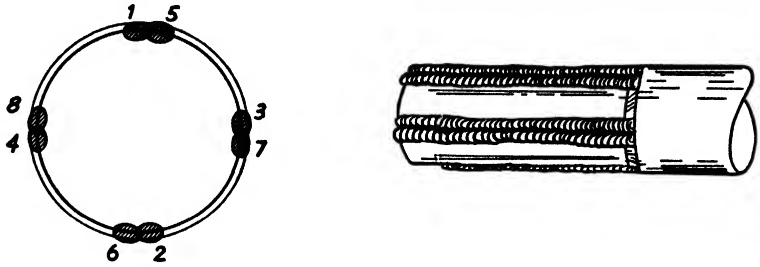


Fig. 16-41. In building up worn shafts or axles, deposit beads alternately to avoid warping.

by turning in a lathe, or by grinding and filing where precision fitting is not required.

Building up flat surfaces Build up flat surfaces by depositing beads side by side with a little overlapping. Use a slight weaving motion to blend the beads together better. On small pieces allow each bead to cool before depositing the next.

Hard surfacing Many machine parts can be hard-surfaced to make them wear longer. Different types of electrodes are available, but heavily coated electrodes with high-carbon-steel cores are probably best for most jobs in the farm shop. Use as low a current setting as possible, and a fairly long arc with a weaving motion, in order to get shallow penetration and a low wide bead. A thin desposit is all that is required, and it should not be fused too deeply into the base metal. See also Chap. 17, "Oxyacetylene Welding and Cutting," page 547, for discussion of hard surfacing with the oxyacetylene torch.

12. CUTTING CAST IRON AND STEEL WITH THE ELECTRIC ARC

Steel and cast iron can be effectively and economically cut with the electric arc. It can be used also to pierce holes in steel and iron. The cuts are somewhat rough, but they are satisfactory for many uses.

Where the edges must be smooth, they can often be dressed with a grinding wheel.

Coated mild-steel electrodes, such as AWS No. E6013, are commonly used for cutting. The ⅛-in. size with high current settings of 180 to 200 amp is best for most cutting jobs on the farm. If an electrode becomes red hot, its current-carrying capacity is reduced and there is excessive melting of metal from the end. Soaking electrodes in water before using helps to keep them cool while cutting.

Cutting steel Start the cut by striking an arc and holding it on the corner of the piece until a deep crater is formed. Then move the electrode forward with the top leaning back and using a short up-and-down swinging motion (see Fig. 16-42). Melt metal on the up-

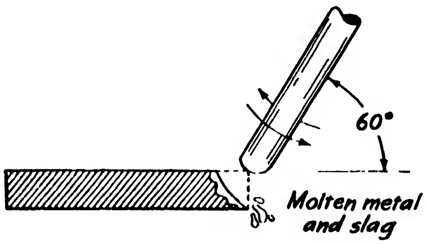


Fig. 16-42. In cutting steel, hold a short arc and use a short swinging motion. Melt metal on the upstroke and drag molten metal out on the downstroke.

swing, and drag molten metal out of the cut with the tip of the electrode on the downswing. Be sure the electrode tip comes all the way down on the downswing to thoroughly clean molten metal and slag from the cut.

Piercing holes in steel To pierce a hole in thin steel, strike an arc and hold it until a large crater is melted; then push the electrode straight down through the piece. If a larger hole is needed, play the arc on the edge of the hole, using a circular motion and pushing the molten metal out with the end of the electrode. Driving a punch of suitable size into the hole while the metal is still hot will smooth it.

In piercing holes in material thicker than ¼ in., it is better to start the hole from the bottom side to allow the molten metal to run out, or to place the work on edge and pierce the hole through horizontally. Molten metal can then run down the side. Globules that stick to the side can be cut off with a chisel.

Cutting cast iron Cast iron is cut with the electric arc in much the same way as steel. In cutting thick castings, or in cutting cast

iron in certain positions, it may be necessary to use more of a gouging motion to remove molten metal and slag from the cut. Where possible, place the part in such a position that molten metal can run down out of the cut.

Cutting with safety In cutting with the electric arc, use special care to avoid burns and fire caused by hot metal falling about. Use a container to catch the hot metal as it falls. Also, keep pants cuffs turned down over the shoe tops. Do not cut around combustible or flammable materials. When cutting galvanized metal, be especially careful not to inhale the fumes. Do not attempt to cut barrels or other containers which have held gasoline, oil, or other flammable material without first having them thoroughly cleaned with a steam cleaner or by other suitable methods (see page 493).

13. CONTROLLING EXPANSION AND CONTRACTION

When metal parts are heated, they expand or stretch; when they cool, they contract or shrink. Uneven heating and cooling of a part sets up stresses inside the metal which may cause warping, and which in turn may also cause cracking or breaking. This is particularly true of

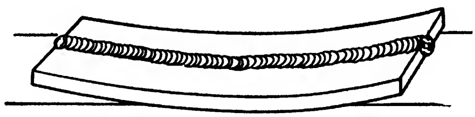


Fig. 16-43. Warping caused by shrinking of bead upon cooling.

weaker metals, such as cast iron. It is important, therefore, that the operator understand these forces and use methods which will counteract them.

When a bead of weld metal cools, it may distort or bend parts or pull them out of line as shown in Fig. 16-43. Another common kind of distortion is upsetting or thickening of the metal. This occurs where the heated metal is surrounded by cold metal or otherwise held and prevented from moving.

Various methods are used to minimize troubles from expansion and contraction. Using as little heat as possible, or depositing small beads, is recommended where expansion and contraction would be especially troublesome. Tack welding of parts to hold them in place, or the use of clamps while welding, is often helpful. Parts may often be positioned

out of alignment, depending upon the contraction of the weld to draw them into proper position (see Figs. 16-44 and 16-45).

Skip welding Figure 16-46 shows skip welding, or the welding of short beads at intervals along a joint. Skip welding is often used to lessen distortion. After the first short beads have cooled, the weld may be completed by filling in other short beads.

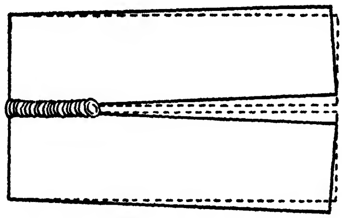


Fig. 16-44. Note that the plates are spaced apart slightly more at one end. When welded, the cooling and shrinking of the bead will pull them into alignment.

Fig. 16-45. Parts may be placed a little lower at the edges than in the center, so that when the weld cools they will lie flat.

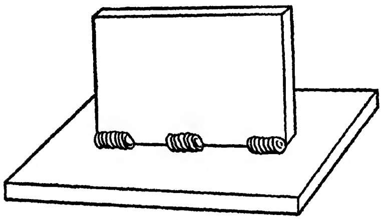


Fig. 16-46. Skip welding to prevent distortion. Short beads are welded at intervals, and then the weld is completed by filling in short beads after the first ones have cooled.

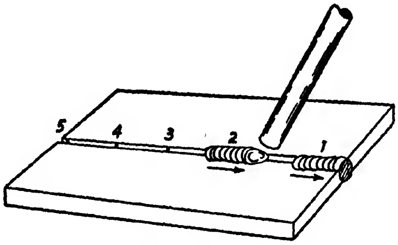


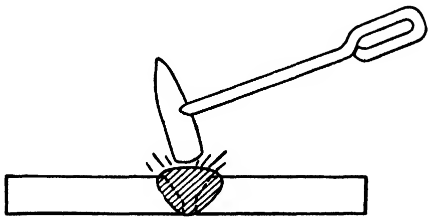
Fig. 16-47. Back-step welding. Start a bead a short distance from the end and weld toward the end. Start the second bead a short distance back from the first one and weld toward it; and so on, welding a series of short beads.

Back step welding This is similar to skip welding. The parts are first tack-welded in place. Then a bead is started a short distance from the end and welded toward the end. A short space is left and a second bead started and welded to the beginning point of the first one, and so on (see Fig. 16-47).

Distortion in some welds may be prevented by peening or hammering them as they cool. The hammering spreads or stretches the metal and counteracts the contraction due to cooling.

Preheating is often done in welding metal that is hard and brittle, like cast iron. Preheating slowly and evenly gives even expansion without serious stresses. The parts are welded while hot, and then they must be slowly and evenly cooled to avoid stresses that might cause cracks. Where it is not practical to preheat, a part subject to serious difficulty from expansion and contraction may often be satisfactorily welded by depositing a series of short beads, allowing each one to cool

Fig. 16-48. Peening a weld as it cools causes the metal to spread and stretch and thus counteracts the contraction that results from cooling.



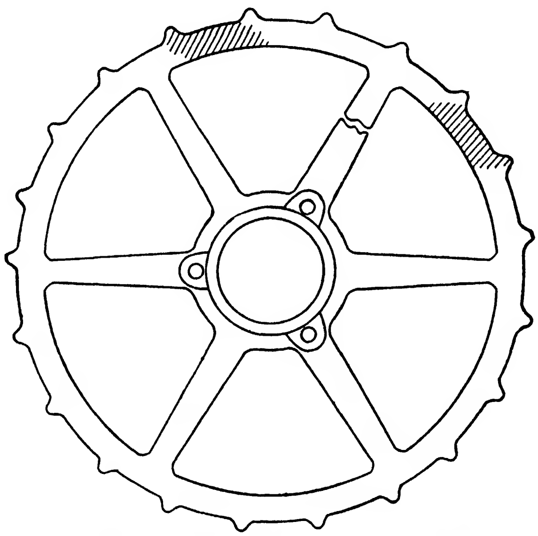


Fig. 16-49. In welding a cracked spoke, preheat sections of the rim to avoid cracking of the weld upon cooling.

before depositing the next. Light peening while cooling is also helpful, as this spreads and stretches the metal, counteracting the contraction due to cooling.

In welding parts like spokes in a sprocket or gear (see Fig. 16-49), it is advisable to preheat certain sections of the rim to avoid cracking of the weld upon cooling. When the heating is properly done, all parts, including the welded part, will cool and contract evenly without cracking.

14. USING THE CARBON ARC TORCH

The arc torch generates an intense heat by means of current which flows and forms an arc between the ends of two carbon rods spaced a short distance apart.

Selecting carbons for the arc torch Copper-coated soft-center carbons are commonly used on a-c arc welders. The size of carbons needed depends principally upon the thickness of the metal to be heated and the amount of heat applied. Carbons ¼ in. in diameter are used on very thin-gage metal. The most common sizes used in the farm shop are 5/16 in. and ⅜ in.

Adjusting the carbon If the ends of the carbons have become burned irregular in shape, trim them or turn them in their holders so

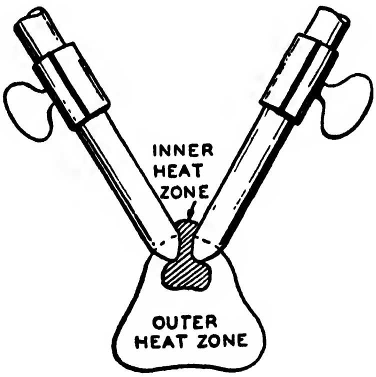


Fig. 16-50. Set the carbons of the arc torch to project 2 to 3 in. from the holders, and turn them or trim them so that they have even surfaces opposite each other. (James F. Lincoln Arc Welding Foundation)

that the tips have smooth and even surfaces opposite each other, and so that they will make good contact when they are brought together. Also, adjust the carbons so that they will project about 2 or 3 in. through the holders.

Adjusting the current and manipulating the arc flame The cables of the arc torch may be connected direct to the terminals of the welder or to the electrode holder and the ground clamp. Set the current according to the thickness of the metal to be heated and the size of carbons used. Carbons of 5/16-in. size usually operate at current settings of 30 to 70 amp, and carbons of ⅜-in. size at settings of 40 to 90 amp.

Once the welder is set for the desired current, make sure that the

carbons are apart and then turn on the welder. Bring the carbons together for an instant to start the arc, and then separate them about $\frac{1}{16}$ to $\frac{3}{16}$ in. to give a quiet, soft flame. *Be sure to have the helmet or hand shield in place before starting the arc.* The best adjustment can be determined by watching the flame. Too short an arc gives a loud crackling noise, and too long an arc results in a lean, weak arc. A wide gap gives more heat, and a short gap less heat. If the carbons become red for a distance of more than 1 to $1\frac{1}{2}$ in. back from the tips, they are operating at too high a temperature.

The heating of the work may be controlled by the distance the arc is held from the work, as well as by the spacing of the carbons and the current setting of the welder. For intense heating of a small area, hold the arc close to the work, to within $\frac{1}{8}$ in. For more general heating of a piece, hold the arc flame further away and play it back and forth over it.

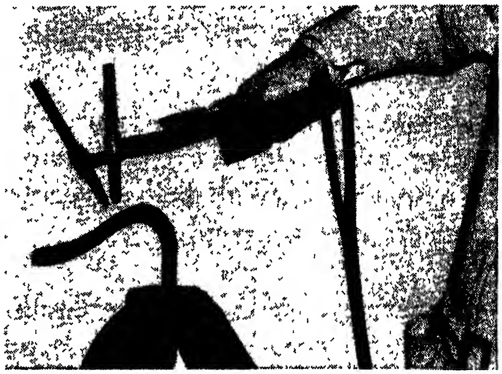


Fig. 16-51. The arc torch is useful for heating parts to bend, as well as for braze welding and for preheating parts to be welded. (James F. Lincoln Arc Welding Foundation)

Braze welding with the arc torch See pages 541–547 for a discussion of the general principles of braze welding, also called bronze welding. Braze welding with the arc torch is done in the same general way as with the oxyacetylene flame. The metal must first be cleaned and prepared. It is then heated to a dull red and tinned, that is, coated with a thin layer of bronze. Flux must be used and may be applied by dipping the end of a heated bronze welding rod into the flux, or by using a flux-coated rod. Because of the dark color of the lens in the face and head shield, it is difficult to see when the metal is at the correct temperature, and other methods need to be used to help judge when the metal is heated enough. A good way is to withdraw the arc momentarily and rub the end of the bronze filler rod on the metal. If the metal is properly fluxed and heated to a suitable temperature,

the bronze will melt from the end of the rod and flow out evenly over the heated surface. If the work is not hot enough, the bronze will not spread, but will tend to stick and remain in small balls or drops. If the work is too hot, the bronze will burn, giving off fumes and forming drops which roll around but will not stick.

There may be a tendency for the bead to become too wide as the arc flame spreads out and heats a fairly wide strip. This may be at least partly overcome by using a close adjustment on the carbons, and by keeping the flame down close to the work.

Braze welding with a single carbon A single carbon mounted in the electrode holder may be used to heat parts to be braze-welded. The parts must, of course, first be properly cleaned and prepared. Braze welding is then done in much the same way as with the oxy-acetylene flame. A flux-coated bronze filler rod or a bare rod may be used. If a bare rod is used, the flux is applied by heating the end of the rod momentarily and then dipping it into the container of powdered flux.

A small-size carbon of about $\frac{3}{16}$ in. is usually best, and the current setting needs to be rather low, from 20 to 50 amp. Tapering the carbon to a small point will help concentrate the flame to a small space. A short arc is recommended.

Soldering with arc welding equipment Soldering can be done with a single carbon also, or with a carbon arc torch. For information on this subject see Chap. 11, "Soldering and Sheet-metal Work," page 347.

JOBS AND PROJECTS

1. Examine an electric arc welder, read and study the operating instructions, and acquaint yourself with all controls, adjustments, and safe methods of operation.

2. Practice making welds in scrap material until you can do creditable work. Refer to the preceding chapter frequently for suggestions on proper methods of procedure. Clamp your practice welds in a heavy vise and bend the pieces, possibly cutting some with a cold chisel. Inspect the welds for flaws or weaknesses. Then make other practice welds and see if you can improve your work.

3. Make a list of several small appliances, such as shoe scrapers, clevises, end-gate fasteners, soil samplers, gate hinges, hose racks, etc., which involve metalwork and welding, and which you would like to make and use. Consult shop books, shop manuals, and farm papers for suggestions.

4. Make plans for the jobs selected above, including lists of materials, and proceed to make them. Carefully observe the principles of good welding to ensure good work.

5. Design some pieces of equipment such as a ladder, a two-wheeled utility hand truck for moving sacked feed, cream or milk cans, or other heavy material. Assemble all materials and make it.

6. Inspect several farm machines for broken or worn parts that can be repaired by welding. Remove them or repair them in place by welding, or make new parts and install them.

7. Hard-surface some parts of farm implements such as cultivator shovels or plowshares, using the carbon arc torch.

8. Repair some bucket or tub or other piece of sheet-metal equipment by means of soldering with the carbon arc torch or with a small carbon electrode in the regular electrode holder.

17 OXYACETYLENE WELDING AND CUTTING

OXYACETYLENE welding and cutting equipment is very valuable in the farm shop, and under some conditions it is preferred over arc welding equipment. Various kinds of welding, heating, and cutting may be done with it. It has not had wide use in farm shops, however, because of the inconvenience of exchanging empty oxygen and acetylene cylinders for full ones, and the rental or demurrage charges on cylinders kept longer than a certain period, usually 30 days. To overcome this objection, however, small-size oxygen and acetylene cylinders have been made available on a purchase or lease basis without rental or demurrage charges. An oxyacetylene welding and cutting outfit equipped with these smaller cylinders costs considerably less than a farm-type a-c arc welder. Such an outfit (see Fig. 17-1) is light in weight and is easily moved to wherever welding or cutting is to be done.

While oxyacetylene is not as fast as arc welding, it is considered better for some kinds of work, such as braze welding, building up worn surfaces, hard surfacing, and some heating jobs. Also, cutting with the

oxyacetylene flame is more satisfactory for most jobs than cutting with the electric arc. See Chap. 16, "Electric Arc Welding," page 478 for other comparisons of arc and gas welding. Many of the better-equipped farm shops have both arc-welding and oxyacetylene equipment, because each has its advantages and one supplements the other.

1. KINDS OF OXYACETYLENE WELDING

Oxygen and acetylene, when mixed in the correct proportions and burned, produce an extremely hot flame that will readily melt metals. If two pieces of steel are brought together and heated at the joint with the oxyacetylene flame, the edges will fuse or melt and run together. This is known as *fusion welding*.

Another type of welding commonly done with the oxyacetylene flame is *braze welding* (also called *bronze welding*). It is used on cast iron, brass, and copper, and also on steel. In braze welding, the surfaces to be joined are not fused or melted. They are simply brought together and heated to a red heat, and then coated with molten bronze from a bronze welding rod with the aid of a flux. Additional bronze is then added to increase the size and strength of the weld.

Fig. 17-1. An oxacetylene welding outfit with small-size oxygen and acetylene cylinders on a small truck.

The oxyacetylene flame is also used effectively in joining pieces by *silver brazing*. In this process, the parts are placed in position, treated with flux, and heated to a red heat. The filler rod, which is composed of an alloy of silver, copper, and zinc, is then melted on the joint, and capillary action draws it into the joint.

Bronze surfacing and hard surfacing are two other processes readily performed with the oxyacetylene flame and which have many applications in the repair of farm machinery. Worn surfaces are easily built up with bronze by the braze-welding process. This process is called bronze surfacing. In hard surfacing, a thin layer of hard, wear-resistant

alloy is applied to the wearing surface to be protected. It is quite similar to braze welding.

2. EQUIPMENT FOR OXYACETYLENE WELDING AND CUTTING

The oxyacetylene welding outfit, as commonly used, consists of a supply of oxygen and acetylene under high pressure in cylinders, pressure regulators, a blowpipe or torch, hoses, connections, and accessories like goggles and a lighter (see Figs. 17-1 and 17-2). The oxygen and

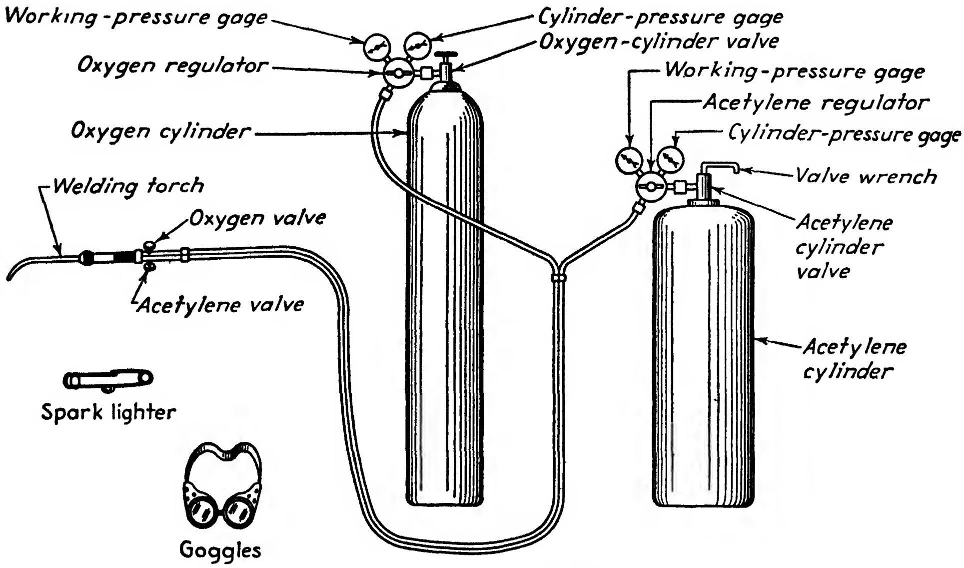


Fig. 17-2. The parts of an oxyacetylene-welding outfit.

acetylene supply cylinders are connected to the torch or blowpipe through pressure regulators and hoses. The torch mixes the two gases in proper proportions and controls and directs the flame. Goggles with colored lenses are used to protect the eyes from glare and flying bits of hot metal.

A welding table with a top of firebricks is needed for oxyacetylene welding. Such a table with a framework of angle iron and bars or steel plate to support the bricks can be made easily in the shop. The height of the table should be about 32 in.

A truck for the cylinders, while not absolutely essential, is quite desirable for portability. A suitable truck can be made in the shop.

A cutting attachment for the welding torch is commonly purchased for use in the farm shop, rather than a cutting torch.

Selecting welding rods and fluxes for the farm shop All-purpose mild-steel welding rods are used for general welding of mild and low-carbon steels in the farm shop. Cast-iron rods are used for welding cast-iron parts, and bronze rods for braze welding. No flux is required for fusion welding of steel, but a cast-iron-welding flux is required for welding cast iron, and a braze-welding flux is required for braze welding. The quantities listed in Table 17-1 are enough to last for several weeks in an average farm shop.

TABLE 17-1. Suggested Quantities of Gas Welding Rods and Fluxes for the Farm Shop

Kind	Size, in.	Quantity, lb
Mild-steel welding rods	3/32	2 or 3
Mild-steel welding rods	1/8	2 or 3
Bronze welding rods	1/8	3
Bronze welding rods	3/16	3
Cast-iron welding rods	1/4	2
Braze-welding flux		1
Cast-iron-welding flux		1

Following safety rules in handling and using oxyacetylene equipment Acetylene is a fuel gas and will burn readily; and oxygen supports combustion and will cause oil and grease and such materials to burn with great intensity. It is evident, therefore, that great care must be used in handling acetylene and oxygen. It is a good plan to read and study the specific safety instructions which may be furnished with a welding outfit. A few of the more important safety precautions are listed below.

General safety precautions

1. Keep acetylene and oxygen cylinders away from fire, furnaces, or radiators.
2. Handle cylinders carefully. Rough handling may damage them or cause leaks.
3. Always open cylinder valves *slowly*.

4. Never use oxygen or acetylene direct from cylinders without pressure-reducing regulators.
5. Keep oxygen away from oil or grease. Do not handle oxygen cylinders or apparatus with greasy hands.
6. Do not weld around combustible materials.
7. Do not allow flame or hot metal to come in contact with hoses or other parts of the welding equipment or with clothing.
8. Weld in well-ventilated places, particularly when doing braze welding or welding of galvanized iron.
9. Never weld without goggles.
10. Never lay a lighted torch down.
11. Do not hang the torch and hoses on the cylinder valves or regulators.

3. SETTING UP AND OPERATING OXYACETYLENE EQUIPMENT

To insure satisfactory results, oxyacetylene equipment should be set up and operated in a careful and systematic manner. The more important points are outlined in the following pages.

Attaching regulators and connecting hoses and torch Before attaching a regulator to a cylinder, open the cylinder valve slightly for a second or two to blow out any dust and dirt that may have accumulated. Then wipe off the connections and attach the regulators. Draw up the nuts with a wrench, but never force them. *Oxygen connections have right-hand threads and acetylene connections left-hand threads.*

Connect the green hose to the oxygen regulator and the red hose to the acetylene regulator. Then connect the other ends of the hoses to the torch, the green hose to the oxygen connection and the red one to the acetylene connection. Draw the nuts up moderately tight with a wrench, but do not force them.

Selecting size of torch tip Select a tip of a size suitable for the welding to be done, and put it on the torch. Use small tips for thin metal, and larger ones for thick metal. Too large a tip overheats the work, while too small a tip heats slowly and is inefficient in the use of gases. It may also cause backfires (see page 534). Instructions furnished by the manufacturer of the torch indicate the sizes of tips to use.

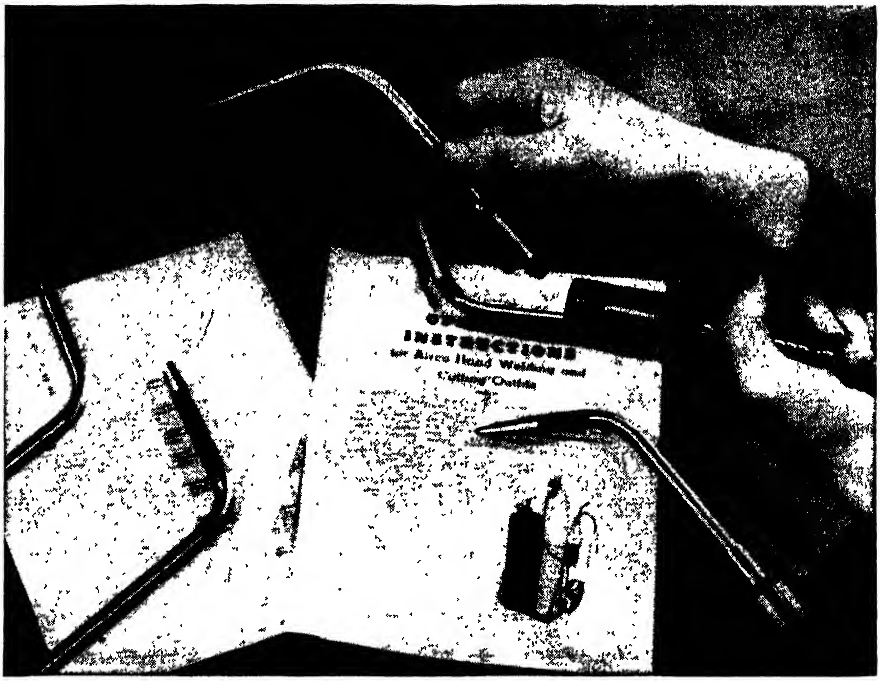


Fig. 17-3. Select small tips for thin metal, and larger ones for thick metal. Consult the instructions that come with the torch.

Turning on the gases and adjusting the pressures Before opening the oxygen and acetylene cylinder valves, back out the pressure-regulator adjusting screws by turning them to the left until they are loose. This closes the regulator valves. Then open the cylinder valves *slowly*—the oxygen cylinder valve fully, and the acetylene cylinder valve no more than 1½ turns. Always leave the acetylene cylinder valve wrench in place so that it can be turned off quickly if necessary. The knob of the oxygen valve is not removable and therefore always remains in place.

Open the torch acetylene valve and adjust the acetylene pressure regulator to give the desired working pressure. Then close the torch acetylene valve. Adjust the oxygen pressure in the same manner. Different models of torches use different pressures. Manufacturers furnish tables of working pressures for different models of torches and different sizes of tips.

Testing for leaks After the equipment is set up and connected, it is a good plan to test the connections for leaks. This may be done by

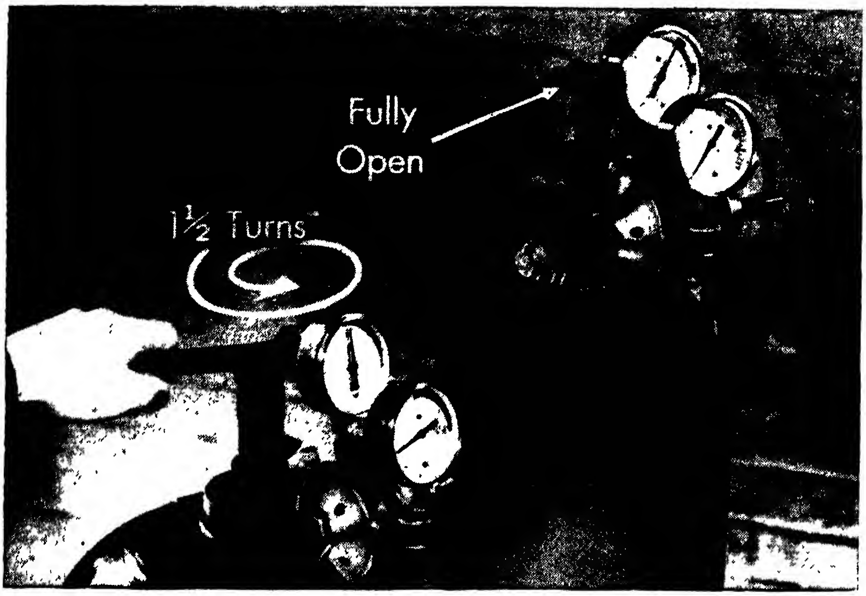


Fig. 17-4. Open the cylinder valves slowly—the oxygen valve fully but the acetylene valve no more than 1 1/2 turns.

Fig. 17-5. With the torch acetylene valve open, adjust acetylene pressure regulator to desired pressure. Then close the torch valve. Adjust the oxygen pressure the same way.

Fig. 17-6. After pressure regulators have been set, open the torch oxygen valve about a one-eighth turn and the acetylene valve about a quarter turn, and light the flame with a spark lighter.

applying clean soapy water to the connections with a small paintbrush. If any connection shows a leak, take it apart and wipe it carefully. Then reassemble it and tighten it firmly, but do not force it. Hoses may be tested for leaks by submerging them in water.

Lighting the torch and adjusting the flame Different methods are used in lighting a torch and adjusting the flame. It is usually best to follow the manufacturer's instructions for a particular model. In the absence of such instructions, the following procedure may be used:

1. After the pressure regulators have been set to give the approximate working pressures, open the torch oxygen valve just a little, possibly ⅛ turn, and the torch acetylene valve about ¼ turn.

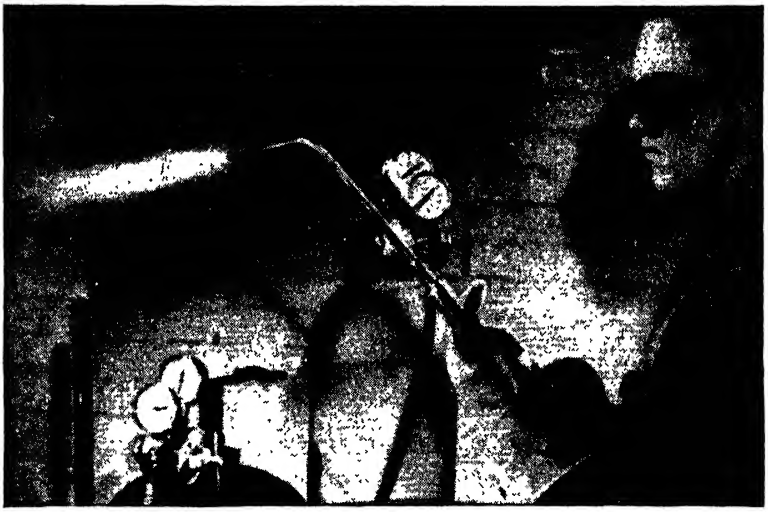


Fig. 17-7. Open torch oxygen and acetylene valves alternately a little at a time until they are fully open. Adjust pressure regulators to give an excess-acetylene flame, and then close the torch acetylene valve just enough to give a neutral flame.

2. Light the flame with a spark lighter. Using a match may result in hand burns.
3. Open the torch oxygen valve and the torch acetylene valve alternately, a little at a time, until they are fully open.
4. Adjust the flame with the pressure-regulator screws to give about a 3X or 4X excess-acetylene flame (see the following topic on types of flames).
5. Make the final adjustment to a neutral flame by turning the torch

acetylene valve to the right, reducing the amount of acetylene until the outer white cone just disappears or merges with the inner cone.

Types of flames A flame with an excess of acetylene is called an *excess-acetylene* flame, or a *carburizing* or *reducing* flame. One with an excess of oxygen is called an *oxidizing* flame, or an *excess-oxygen*

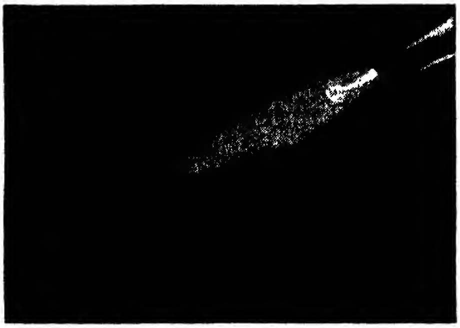


Fig. 17-8. An excess-acetylene flame. Note the two white cones at the tip of the torch.

Fig. 17-9. A neutral flame. To obtain a neutral flame, first adjust to an excess-acetylene flame, and then reduce the acetylene until the outer cone just disappears or merges with the inner one.

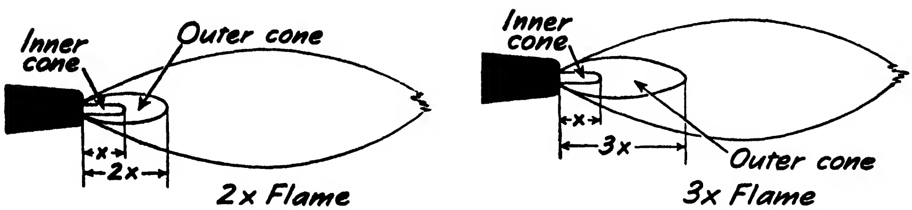


Fig. 17-10. A flame with the outer cone or acetylene feather twice as long as the inner cone is called a 2X flame. Likewise, if the outer cone is three times as long as the inner one, it is called a 3X flame.

flame; and one with an excess of neither acetylene nor oxygen is called a *neutral* flame.

With an excess-acetylene flame there will be two white cones at the tip of the torch (see Fig. 17-8). As the amount of acetylene is reduced, the outer cone, or acetylene feather, becomes shorter. When it just disappears or merges with the inner cone, the flame is neutral. For some kinds of work, as in welding certain alloy steels, and in hard surfacing, an excess-acetylene flame is needed. The amount of excess acetylene

is important and is indicated by the lengths of the inner and outer cones. For example a flame with the outer cone twice the length of the inner one is called a *2X flame,* and one with the outer cone three times as long as the inner one is called a *3X flame* (see Fig. 17-10).

Most welding is done with a neutral flame. Since there is very little difference in the appearance of a neutral flame and one which is slightly oxidizing, it is easier to get an exactly neutral flame by adjusting from an excess acetylene flame rather than from an excess oxygen flame. When welding with a neutral flame, it is important to inspect it frequently and make sure that it stays neutral. This is easily done by opening the torch acetylene valve a little to produce an excess-acetylene flame and then closing it until the outer cone just disappears.

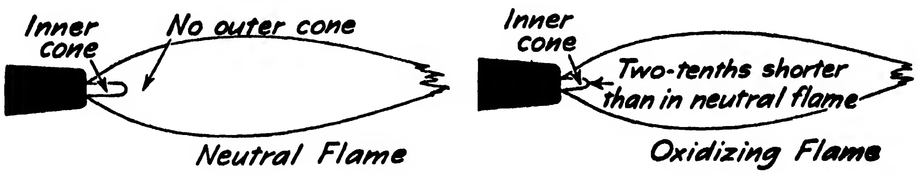


Fig. 17-11. With an oxidizing flame the inner cone is shorter than in a neutral flame. The approximate adjustment is indicated by the amount of shortening, as two-tenths, for example.

For some work, as in braze welding, a slightly oxidizing flame is needed. The approximate adjustment of such a flame may be indicated by the amount of shortening of the inner cone from the neutral adjustment, for example, one-tenth, or two-tenths (see Fig. 17-11).

Stopping work To turn off the torch, simply close the valves on the torch, the acetylene valve first and then the oxygen valve. If work is to be stopped for only a minute or two, such as for placing or aligning work on the welding table, nothing more need be done.

When a job is finished or when welding is to be stopped for several minutes, then also close the cylinder valves and drain the hoses, using the following procedure to avoid mixing of oxygen and acetylene in the hoses or torch:

1. Close the acetylene and oxygen cylinder valves.
2. Open the torch acetylene valve, keeping the oxygen valve closed, to drain the hose. Release the adjusting screw on the acetylene regulator, turning it to the left. Then close the torch acetylene valve.

3. Open the torch oxygen valve, keeping the acetylene valve closed, to drain the oxygen hose. Release the adjusting screw on the oxygen-pressure regulator, turning it to the left. Then close the torch oxygen valve.

Controlling backfires and flashbacks Sometimes when welding, the torch will backfire, or go out with a loud snap. Usually it can be relighted from the hot metal being welded. Backfires may be caused by touching the tip against the work, by overheating of the tip, by not using the correct gas pressures, or by a loose tip (which prevents it from cooling properly).

A flashback, or a burning back inside the torch, indicates that something is radically wrong with the torch or the manner in which it is operated. Should a flashback occur, shut off the oxygen at once, and then the acetylene, and examine the torch thoroughly. If it appears to be in good condition, relight it, being sure to use the gas pressures recommended and to operate the torch in an approved manner. If flashbacks continue, send the torch to the manufacturer for repair.

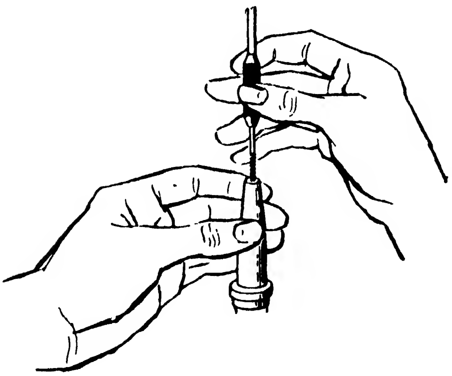


Fig. 17-12. To clean a torch tip, use a tip cleaner of the correct size. Work the cleaner straight up and down. Do not twist.

Keeping tips in good condition After considerable use, a welding-torch tip is likely to be partly clogged with spatter or other foreign material. Cleaning the tip with a proper-size drill or tip cleaner as specified by the manufacturer is usually all that is required. Nothing except a proper-size drill or tip cleaner should be used, however, as the orifice in a tip can be easily damaged with a wire or a tool not designed for this work. In using a drill, push it straight in and out. Do not turn or twist it.

After long use, the end of the hole in the tip may become rounded or slightly funnel-shaped instead of perfectly straight and square. Usually such a tip can be reconditioned by holding it perpendicular against an oilstone or emery cloth on a flat surface and rubbing it back and forth. Running a tip cleaner through the hole will remove any small burr left by honing.

4. FUSION WELDING

Fusion welding is the joining of pieces of metal by heating the adjoining edges to the fusion or melting point and allowing them to flow or run together and then cool.

Preparing joints for welding The method of preparing the work for fusion welding with the oxyacetylene torch is essentially the same as preparing it for arc welding. First clean the work of rust, paint, scale, grease, and other foreign material. Steel up to ⅛ in. in thickness may be butt-welded without grooving, but joints in steel over ⅛ in. thick should be grooved or veed to give good fusion. A single groove on one side is enough for metal between ⅛ in. and ⅜ in. thick. Usually a groove is made on each side of metal over ⅜ in. thick.

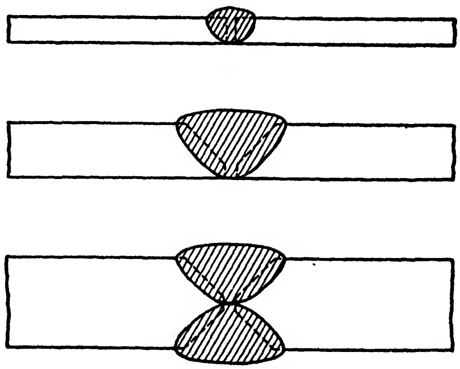


Fig. 17-13. Time spent in cutting up grinding V grooves and in fitting or work preparatory to welding is time well spent. Pieces 1/8 in. thick and under may be welded without grooving. Where ever possible make a V groove on each side of pieces over 3/8 in. thick.

Carrying a puddle without welding rod Success in welding depends upon the ability to control the size of the molten puddle of metal and to carry it along uniformly as a weld is made. It is therefore better for a beginner to learn to carry a puddle on a piece of steel as outlined in the following paragraph before attempting to weld two pieces together.

Use a piece of steel about ⅛ in. thick for practice in carrying a puddle. Select a tip size suited to this thickness of metal and adjust the working pressures. Light the flame and adjust it to neutral. Hold the tip at an angle of approximately 45 deg to the surface of the work, pointing it in the direction of welding. Hold the torch so that the inner cone of the flame is about ⅛ in. from the metal. Hold it steady until a pool of molten metal forms and is about 3/16 to ¼ in. in diameter. Then move the torch slowly forward, using a circular weaving motion. The speed of forward movement is important. It should be just fast enough to keep the size of the puddle uniform. If it is too fast, the puddle will be too small and there will be insufficient penetra-

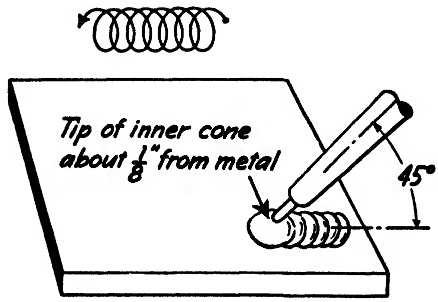


Fig. 17-14. To carry a puddle without a welding rod, move the torch slowly forward, using a circular weaving motion. Adjust the speed of movement to keep the puddle of uniform width.

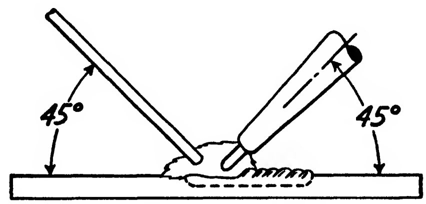


Fig. 17-15. In depositing a bead, move the puddle gradually forward, using a circular weaving motion. Add metal from the welding rod by dipping it into the puddle at regular intervals. Do not let metal drip from the rod.

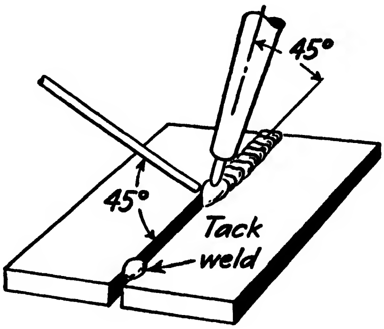
tion; if it is too slow, the puddle will get too large, giving a wide bead, and there may be danger of melting through on thin material. If the puddle gets too large, lift the torch for an instant to allow the metal to cool. Practice carrying a puddle without the use of a welding rod until a uniform ripple effect is easily made.

Carrying a puddle with welding rod Carrying a puddle with a welding rod is done in much the same manner as without, except that metal is added to the puddle by melting from the rod to build a bead. Hold the tip at an angle of approximately 45 deg with the surface, pointing it in the direction of welding, and hold the rod at about 45 deg with the end pointing down into the flame (see Fig. 17-15). Hold the flame in one place until the puddle starts to form, heating the end

of the filler rod at the same time by holding it in the outer envelope of the flame. When the puddle is formed, dip the end of the rod into it and melt off a little metal, and then move the end of the rod back up into the outer envelope of the flame. Move the puddle gradually forward, using a circular or oval weaving motion of the torch, and adding a little metal from the welding rod by dipping it into the puddle at regular intervals. Do not let metal drip from the rod. A uniform width and height of bead may be produced by welding at just the right speed. If the torch is moved too slow, the puddle will become too large and may melt through; if it is moved too fast, the bead will be too narrow and will be poorly fused with the base metal.

Making butt welds in steel To make a butt weld in steel of ⅛ in. thickness or under, place the edges of the parts together, leaving a space of about half the thickness of the metal between them. Tack-weld

Fig. 17-16. In welding thin steel—⅛ in. and under—space the parts about one-half their thickness and tack-weld. Then begin at the right end of the joint and carry the puddle along at uniform speed. Be sure to fuse the joint well all the way through.



the pieces at intervals to hold them in proper alignment, and then start the weld at the right end of the joint (assuming that the operator is right-handed). Hold the flame in one place until the puddle forms and covers the edges of both pieces and penetrates through to the bottom of the joint. Then add metal from the welding rod to build the weld up somewhat higher than the surface of the parts. Move the flame and the rod along, carrying the puddle at a uniform speed, and being sure the joint is well fused.

A similar method is used for butt welding steel thicker than ⅛ in. except that the edges are first veed to ensure good fusion. In metal over ¼ in. in thickness, the weld may be made with more than one pass.

First a bead about an inch long is deposited in the bottom of the groove, and then a second one deposited on top of the first. The bead in the bottom is then extended another inch or so and then built up by depositing another one on top, and so on (see Fig. 17-18).

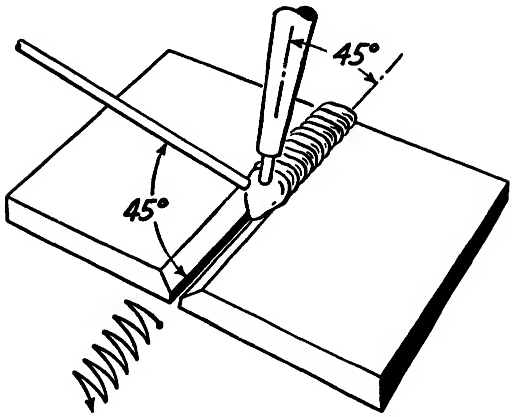


Fig. 17-17. To butt-weld pieces over 1/8 in. in thickness, bevel the edges to ensure good fusion.

Making fillet welds in steel Fillet welds are used principally in lap and tee joints (see Chap. 16, "Electric Arc Welding," page 502). They are made very much the same as butt welds. The parts are first tack-welded at intervals if necessary to hold them in alignment. The flame is then held at the start of the weld until a puddle is formed and the edges of the two pieces are well fused all the way to the bottom of the joint. Metal is then added from the filler rod to build the weld up to the desired strength and shape, and the puddle is moved gradually along the joint, using a weaving motion and being careful to maintain a speed which will give good fusion and a uniform bead. A common difficulty in making fillet welds is uneven heating of the two pieces and failure to bring them to the welding temperature at exactly the same time. Such difficulty can be largely overcome, however, by watching the two surfaces and changing the direction of the flame slightly as may be required, pointing it more directly at the surface which tends to heat too slowly, usually the lower one.

Welding in vertical, overhead, and horizontal positions Although welding in these positions is somewhat more difficult than in the flat position, it can soon be learned by careful attention to a few principles. The puddle must be kept small and shallow and prevented from becoming too fluid. The metal must not be heated to the point where it will form drops. The size of the puddle, the addition of metal to it, and its movement are controlled largely by two special techniques: (1) directing the flame so that the pressure of the burning gases helps to flow the molten metal as desired, and (2) moving the molten metal in the puddle with the end of the welding rod.

Welding in the vertical position Welding in the vertical position is commonly done from the bottom up. Point the torch upward at an angle of about 45 deg and the welding rod downward at about the same angle (see Fig. 17-19). Hold the torch at the bottom of the weld until a puddle is formed, and then add metal from the welding rod. Lift the torch upward a little at regular intervals to allow the metal in the

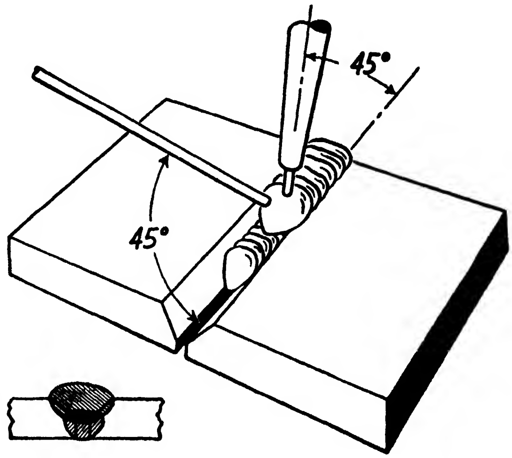


Fig. 17-18. Multiple-pass welds may be used in welding thick metal. First deposit a bead about an inch long in the bottom of the groove, and then a second on top of the first. Extend the beads alternately about an inch at a time.

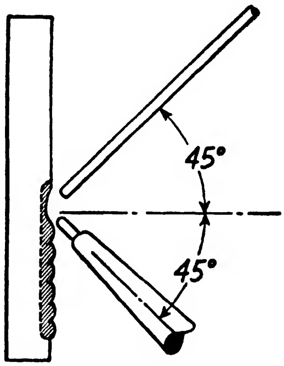


Fig. 17-19. In welding in the vertical position, point the torch upward at about 45 deg and the rod downward at about the same angle. Lift the torch a little at regular intervals to allow the lower part of the puddle to solidify.

lower part of the puddle to solidify and form a small ledge or "shelf" to support the puddle. Then move the torch upward at a steady speed, keeping the puddle shallow and adding metal to build the weld to suitable size. Be sure that the weld penetrates to the bottom of the joint or groove and that it is thoroughly fused.

Welding in the overhead position Welding in the overhead position is done much the same as in the flat position, except that the torch is held at nearly 90 deg to the surface (see Fig. 17-20), a little less heat is used, and the puddle is kept a little smaller and shallower. Overhead welding is often easier than vertical welding or horizontal welding.

Moving the end of the welding rod through the puddle helps to move the puddle along and keep it shallow.

Welding in the horizontal position In welding in the horizontal position, hold the torch and the welding rod at angles of about 45 deg to the work (see Fig. 17-21). Weave the flame back and forth on the edges of the two pieces, holding it longer on the lower piece than on the top one. When the edge of the top piece barely reaches the welding temperature and becomes just plastic, rather than very fluid, add metal. Lift the torch briefly at intervals to allow the back edge of the puddle to solidify. In horizontal welding, moving the rod through the puddle usually gives better control and movement of the puddle than using the blowing action of the burning gases from the torch.

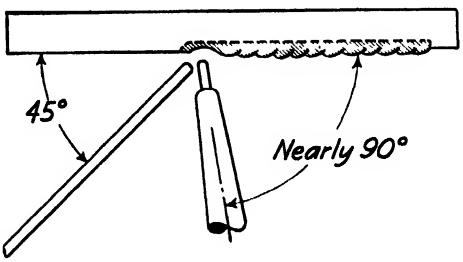


Fig. 17-20. In welding in the overhead position, hold the torch at nearly 90 deg to the surface. Use somewhat less heat than for other positions in order to keep the puddle small.

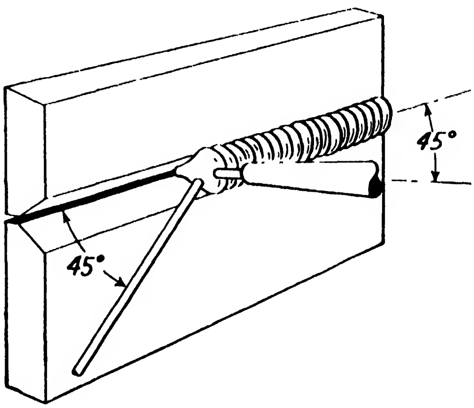


Fig. 17-21. In welding in the horizontal position, carefully control the heating and add metal when the top piece just barely reaches the welding temperature.

Fusion welding cast iron Ordinary iron castings (gray iron) may be satisfactorily fusion-welded, but malleable iron castings cannot. They can be welded, however, by the braze-welding process (see page 541).

Fusion welding of cast iron is done in much the same way as fusion welding of steel, but with a few important differences. A cast-iron filler rod is used instead of a steel one; a special cast-iron flux is used; and special precautions must be taken in heating and cooling. Cast iron is brittle and weak in tension, and uneven expansion and contraction due to uneven heating and cooling may cause cracks. It is best to preheat all but the smallest castings in order to avoid cracking. Some

small or medium-sized castings may be preheated by playing the torch over them occasionally while welding. Large parts may be preheated in a furnace made of fire brick.

Bevel the edges and clean the parts thoroughly the same as in welding steel.

In welding cast iron, the puddle is a little more difficult to control than in welding steel, because molten cast iron is very fluid. Gas bubbles or spots, caused by impurities, appear in the puddle. These may be brought to the surface by playing the flame on them, even dipping the flame momentarily into the puddle, and by moving the welding rod through it. The impurities will stick to the rod and can be removed and shaken off by tapping the rod against the welding table.

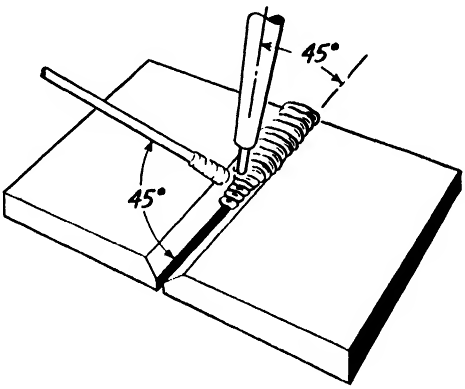


Fig. 17-22. In welding cast iron, use a cast-iron filler rod and a cast-iron flux. Keep the bottom and the edges of the groove well fused with the puddle.

Use plenty of flux in welding cast iron. Be sure to keep the bottom and edges of the groove well fused with the puddle. Add metal until the weld is built up somewhat higher than adjoining surfaces. When a length of weld an inch or so long is done, begin in the bottom of the groove and build up an adjacent section, and so on until the weld is finished. In thick castings, make multiple-pass welds, extending the beads alternately about an inch at a time.

After a casting is welded it is a good plan to play the torch back and forth over it for a minute or two to relieve strains. Then allow it to cool slowly to room temperature. If possible, bury it in dry lime or ashes, or cover it with asbestos paper, to ensure slow cooling.

5. BRAZE WELDING

Braze welding, also called *bronze welding,* is one of the most useful operations done in the farm shop with oxyacetylene equipment. It is

accomplished by heating the work only to a red heat, slightly above the melting temperature of bronze. It is therefore especially suited to welding castings and malleable iron, where heating to a fusing temperature would cause excessive expansion or other undesirable changes, as in the properties of the metal.

Since braze welding is done at a lower temperature than fusion welding, it can be done faster and with a lower consumption of gases. Because bronze loses strength at temperatures above 500°, however, braze welding is not suitable for welding parts which will be subjected to high temperatures.

Braze welding is quite similar to soldering, but is done at a higher temperature. The metal is heated to a red heat and then tinned with a coating of bronze, with the aid of a flux. Under proper conditions a thin coating of bronze covers and adheres perfectly to the surfaces of the parts to be joined. Additional bronze is then deposited from the welding rod to finish the weld and build it to suitable size.

Preparing joints for braze welding of steel Joints of steel parts to be braze-welded must be cleaned of rust, scale, paint, grease, and other foreign material. Oxides on the surfaces must also be removed by the use of a flux. Plain butt joints may be used in thin material, but in work over about 1/8 in. in thickness, grind the edges to form a vee joint in the same manner as for fusion welding. Where possible, parts to be braze-welded should be spaced 1/16 to 1/8 in. apart to ensure penetration of the weld all the way through the joint.

Adjusting the flame and tinning the surface Select a tip of suitable size, usually a size smaller than for fusion welding of parts of the same thickness, and adjust the flame to slightly oxidizing. Acetylene has an undesirable effect on molten bronze. A slightly oxidizing flame is used, therefore, to make sure that no unburned acetylene is present in the flame.

Either a powdered or a liquid flux may be used in braze welding. A powdered flux is usually preferred, and it is applied by dipping the heated welding rod quickly into the can of flux. The flux sticks to the heated rod and can then be readily transferred to the work. Flux-coated bronze rods are also available, but bare rods and separate flux are usually preferred for farm shopwork.

Heat the work to a red heat, holding the torch in the same position

as for fusion welding. It is important not to overheat or melt the surfaces. As the work is heating, heat the end of the bronze welding rod also, by holding it in the outer envelope of the flame. When it is hot, dip it quickly into the flux and bring it back into the flame and lower it down onto the heated metal. If conditions are right, the bronze will melt and flow out evenly in a thin surface over the heated parts. If the work is not hot enough, the bronze will not spread but will tend

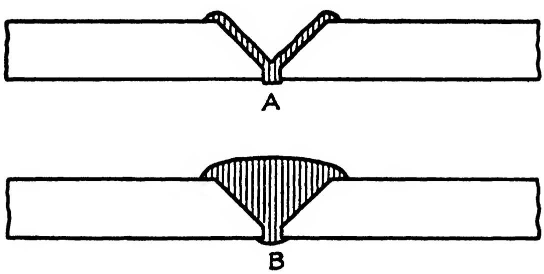


Fig. 17-23. In braze welding, first heat the parts to a red heat and "tin" them with bronze from a bronze welding rod. Then add bronze to build up the weld to a suitable size. Use a slightly oxidizing flame.

to stick and remain in drops. If the work is too hot, the bronze will give off white fumes and form drops which roll around but will not stick. A little experience will enable one to judge the proper temperature.

Adding metal to the weld After the surface is tinned, melt additional bronze from the end of the rod and build the weld to the desired size. Keep the welding rod in the outer envelope of the flame, dipping it at intervals into the puddle to add metal. Add the bronze near the rear of the puddle. Lift the rod away at intervals to heat and tin the joint just ahead of the flame. Move the torch ahead at a slow, steady speed, using a circular motion. Lift it occasionally for an instant if necessary to prevent overheating of the weld. Apply more flux as necessary.

With a little practice, it will be possible to tin the joint just ahead of the flame and to add metal to the weld in practically one continuous operation. It is very important that the surfaces of the joint be thoroughly tinned all the way through to the root or base of the weld. As mentioned previously, it is necessary to use just the right tem-

perature. Difficulties in tinning are often due to overheating or underheating.

In braze welding thick parts which require more than one pass, be sure to fuse each new bead thoroughly into the surface of the one previously deposited.

Braze welding in vertical, horizontal, and overhead positions Braze welding in these positions is done in much the same manner as fusion welding. The main problem is to keep the molten metal under control and to prevent the formation of drops. This can be done by using less heat and by adding only a little metal to the weld at a time.

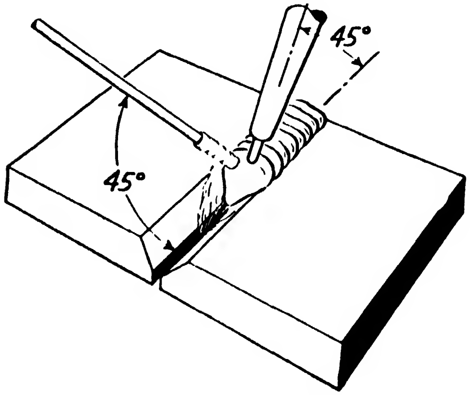


Fig. 17-24. Braze welding. Keep the welding rod in the outer envelope of the flame, dipping it at intervals into the puddle to add metal. Keep the joint tinned just ahead of the flame.

Other techniques of value are using a weaving or circular motion with the torch and lifting it from the surface at intervals to allow the molten metal to cool slightly and solidify.

In making some welds, particularly fillet welds, one piece may tend to heat ahead of the other. In such cases, carefully watch the progress of the tinning of the two surfaces and direct the flame more toward the piece which tends to heat slower. Both parts should tin evenly and just ahead of the weld.

Braze welding cast iron Braze welding is especially good for repairing broken castings. The lower temperatures used reduce the difficulties due to expansion and contraction and often make preheating unnecessary. Bronze yields readily at temperatures above 500°, and it yields somewhat, though less readily, at ordinary temperatures. Braze welding is therefore well suited to welding of castings where stresses from heating and cooling tend to cause cracking.

Malleable iron castings can be satisfactorily welded by braze welding,

but they cannot be welded by fusion welding. Heating malleable castings to the fusion temperatures changes the structure of the metal, destroying its malleability at the place welded and making it brittle. Braze welding, which is done at only a red heat, does not change the structure.

Preparing castings for braze welding Bevel the edges of all cast-iron parts to be braze-welded, even thin ones, by grinding, filing, or chipping with a cold chisel. In a part that is broken in two, it may be better not to bevel the edges all the way through, but to leave a small thickness of the old fracture to help align the parts. Where there

Fig. 17-25. After fusion welding or braze welding a casting, it is a good plan to bury it in dry lime or ashes to ensure slow cooling.

is no problem in alignment of parts, space them about $\frac{1}{16}$ in. apart at the joint to ensure thorough tinning all the way through.

Be sure to remove all paint, scale, grease, and other foreign material from the joint. Washing in kerosene or other suitable solvent, or heating to a black heat for a time, may be required to remove oil from oil-soaked castings.

Small castings can usually be braze-welded without preheating. Even moderately large ones can also be braze-welded by observing special precautions. A long weld, for example, may be made an inch or two at a time, with alternating periods of cooling and welding, so as not to overheat the casting.

Heating and tinning the work Cast iron contains particles of carbon, and beveling the joint by grinding may smear these particles over the surfaces and make tinning difficult. In such cases, sear the surfaces by heating them to a red heat before attempting to tin them, but be careful not to melt them, as this would form scale, which makes tinning difficult.

After searing, tin the parts to be welded, using methods similar to those for tinning steel. Sprinkle some flux on the joint, and then apply additional flux by dipping with the heated bronze welding rod.

Finishing the weld After tinning, add bronze to the weld by dipping the heated fluxed welding rod to the surface at intervals, and build the weld to suitable size. When the weld is completed, it is a good plan to play the torch back and forth over it for a moment or two to relieve strains that may have been set up by unequal expansion and contraction. Then allow the weld to cool slowly to room temperature. Where possible, bury it in dry lime or ashes, or cover it with asbestos paper to ensure slow cooling.

Building up worn surfaces Many worn parts of machines can be easily and effectively built up with the braze-welding process. The

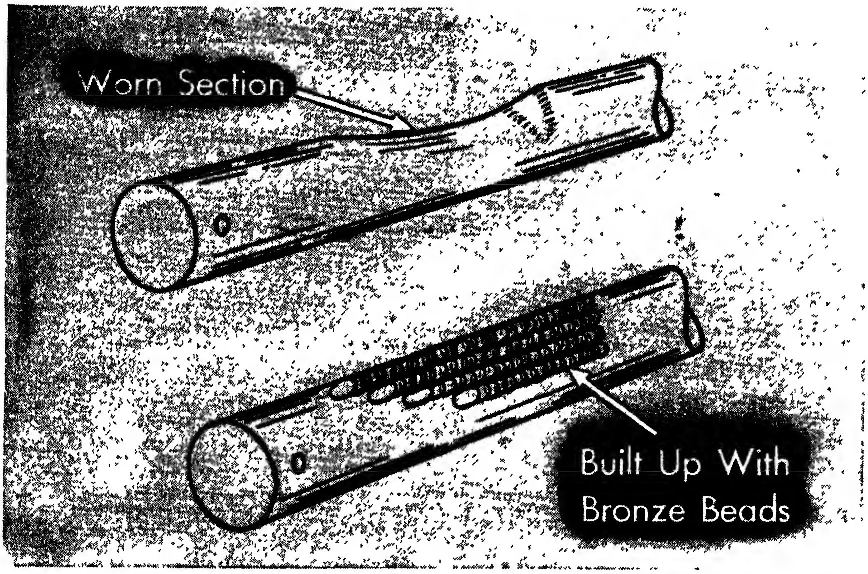


Fig. 17-26. To build up a worn machine part, first clean and tin the surface, and then deposit beads of bronze side by side and on top of each other. Use a small tip so as not to overheat the work already done.

surfaces must be cleaned and thoroughly tinned, and then beads of bronze are deposited beside each other, or on top of others, until the part is rebuilt approximately to the required size. In adding new beads, care must be used not to melt down those previously deposited. It may be best to use a smaller-size tip so as not to overheat the work

already done. Also, the flame may be directed more nearly parallel to the surface, rather than at the usual angle.

After the worn surfaces or parts are built up approximately to size, they may be finished to the required shape and size by filing or grinding. Round parts can often be finished with a lathe if one is available.

6. HARD SURFACING WITH THE OXYACETYLENE TORCH

The edges of many parts of farm machines, such as plowshares, cultivator shovels, harrow teeth, and ensilage-cutter knives, can be hard-surfaced to make them stay sharp longer. The process of hard surfacing

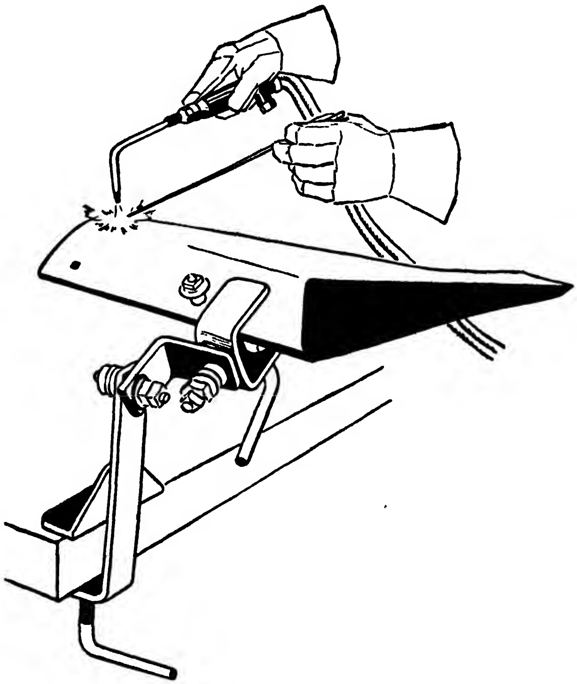


Fig. 17-27. Many farm-machine parts may be hard-surfaced to make them stay sharp longer. The process of hard surfacing is similar to braze welding. Note the universal home-made clamp for positioning parts while hard surfacing or welding.

is very much like the tinning process in braze welding. The surface to be treated is first thoroughly cleaned by grinding and then heated with an excess-acetylene flame until it starts to melt, or "sweat." A welding rod of the hard-surfacing alloy is then touched to the surface and a small amount melted off. If the work has been properly prepared

and heated, the alloy will flow out in an even, thin surface. In hard-surfacing castings, a cast-iron welding flux is commonly used.

Hard-surfacing alloys of various degrees of hardness and toughness are available. The exact amount of excess acetylene in the flame is important. Follow instructions furnished by the manufacturer of the alloy rod. Apply the hard-surfacing alloy with as little mixing with the base metal as possible. Usually a thin layer of the hard alloy is all that is required. In some cases, however, as in hard surfacing the point of a plowshare, a thicker layer is needed. In such cases, apply a thin layer first, and then deposit additional beads, as in building up surfaces with bronze. If the finished surface is somewhat rough, play the torch over it to melt the high spots and fill the low ones. *Do not overheat the work.* Final finishing may be done by grinding, but keep the amount of grinding to a minimum.

Hard-surfacing alloys are very fluid when melted. Parts being hard-surfaced should therefore be held in the flat position.

Hard-surfacing alloys are usually applied to only one side of a wearing part. The softer steel wears away faster than the hard alloy, thus making the part self-sharpening. Plowshares are commonly hard-surfaced on the under side, although the point of the share may have a layer applied to both the bottom and top sides.

Allow parts which have been hard-surfaced to cool slowly in air; or cover with asbestos paper, or bury in dry lime or ashes until cool.

7. SILVER BRAZING

Silver brazing is a process similar to soldering, but it is done at higher temperatures (about 1300 to 1500°). Silver-brazing alloys are composed principally of silver, copper, and zinc. An alloy of about 50 percent silver is used for general-purpose work. The alloy is rather expensive, but only very small amounts are required. This is because close-fitting joints are used, and only a thin film of the melted alloy is needed to fill a joint.

Silver brazing is often used for making connections in fuel and oil lines, in pipes and fittings and tubing in heating and water systems, refrigeration equipment, etc. It may also be used in making joints in dairy equipment, vats, kettles, etc. Breaks in machine parts, particularly small parts, can often be repaired by silver brazing effectively and more easily than by welding.

Prepared commercial fluxes are commonly used, although a homemade flux of common borax dissolved in hot water may be satisfactory.

In silver brazing, clean and flux the parts and then place and hold them in position while they are heated. It is important that close fits, with a tolerance of only a few thousandths of an inch, be maintained. Heating can be done with the oxyacetylene flame or, in the case of small parts, with an air-acetylene flame. Play the flame over the parts so as to heat the entire joint uniformly. When the metal is at a dull red, remove the flame and touch the end of the fluxed silver-brazing wire or strip to the joint. The silver-brazing alloy quickly melts and is drawn into the joint by capillary action.

Just enough heat to melt the brazing wire is all that is required. If the parts are not heated enough, the brazing alloy will form in balls and will not flow out evenly. In such cases, allow the work to cool, and then reflux and reheat it.

8. CUTTING WITH THE OXYACETYLENE FLAME

Steel is easily cut with the cutting torch or with the welding torch equipped with a cutting attachment. Cast iron and certain steel alloys are more difficult to cut than steel. A cutting attachment for the welding torch is commonly used in farm shopwork rather than a cutting torch.

The tip of a cutting torch or of a cutting attachment for a welding torch has a number of small holes arranged in a circle about a central hole. The outer holes supply oxygen and acetylene for preheating flames which heat the metal to a red heat. The central hole supplies oxygen under high pressure, which is turned on by the operator when the metal is at the desired temperature. When the high-pressure oxygen strikes the hot metal, it quickly burns or oxidizes the metal to a molten slag and blows it through, making a cut. As the cutting torch is moved along, a narrow cut or kerf results.

Lighting and adjusting the cutting flame Follow the manufacturer's instructions for lighting the cutting torch and adjusting the flame if they are available. In the absence of such instructions, the following general procedure may be used. Adjust the oxygen-pressure regulator to give the desired pressure (usually about 30 lb per sq in. for cutting metal up to 1 in. thick) with the preheat-oxygen valve closed, but

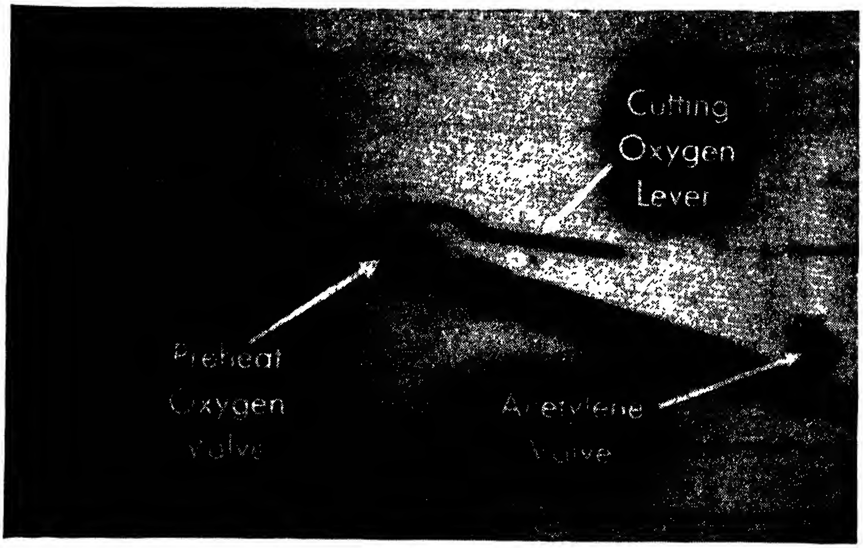


Fig. 17-28. A cutting attachment on a welding torch.

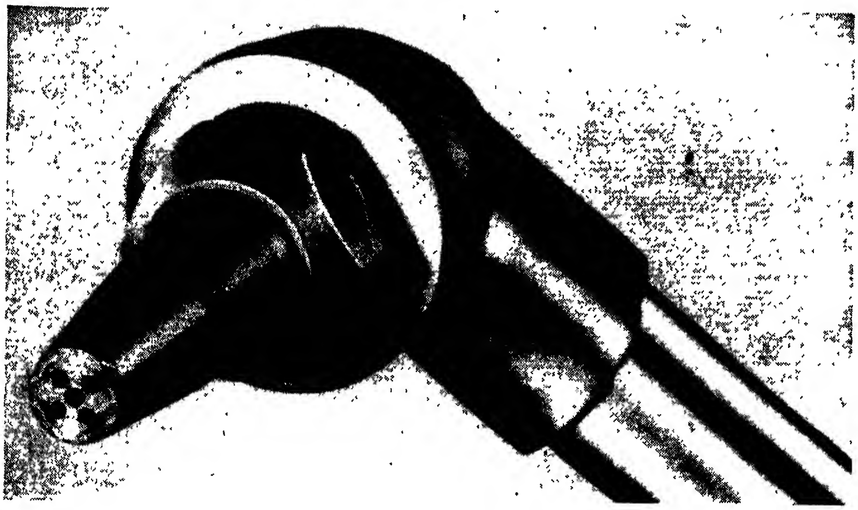


Fig. 17-29. The tip of a cutting torch. The outer holes supply the gases for preheating flames, and the center one supplies the high-pressure oxygen for cutting.

with the cutting-oxygen valve open. Then close the valve. Next adjust the acetylene pressure regulator with the torch acetylene valve open. Close the valve.

Open the preheat-oxygen valve about ⅛ turn and the acetylene valve about ¼ turn. Light the flame with a friction lighter. Open the acetylene valve and the preheat-oxygen valve alternately, a little at a

time, until the acetylene valve is fully open. Adjust the flame to neutral with the preheat-oxygen valve. Then open the cutting-oxygen valve by pressing the lever or trigger, and see if the flame remains neutral. If not, readjust the preheat-oxygen valve until the flame does remain neutral when the cutting-oxygen valve is opened.

Fig. 17-30. Light and adjust the preheat flames to neutral, and make sure they stay neutral when the cutting oxygen valve is opened. Readjust if necessary.

Cutting steel To cut steel, hold the tip perpendicular to the surface with the inner cones of the preheating flames almost but not quite touching the metal. When the metal becomes a bright red, open the cutting-oxygen valve and move the torch slowly and steadily along the

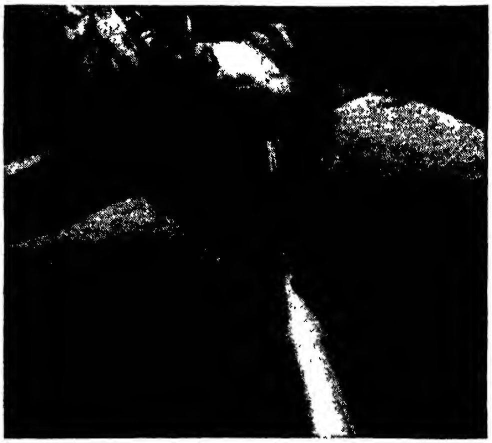


Fig. 17-31. To cut steel, hold the tip about perpendicular to the surface with the inner cones of the preheat flames almost touching the metal. When the steel becomes a bright red open the cutting-oxygen valve and move the torch steadily along.

cutting line (see Fig. 17-31). If the torch is moved too slowly, the preheat flames will melt the edges of the cut and leave it rough; and if the torch is moved too fast, the preheat flames cannot heat the metal sufficiently, and the cutting action will stop. In case the cutting stops, close the cutting-oxygen valve and hold the torch still until the metal

again reaches a red heat. Then open the cutting-oxygen valve and proceed as before, but at a slower speed.

While the torch may be guided along the cutting line by hand, a straight-edged bar clamped along the cutting line to guide the tip is a great help in making straight cuts. If the torch is to be guided by hand, hold it with both hands about 8 to 10 in. back from the nozzle, with the knuckles of the left hand down and resting firmly against the table or some other solid support (see Fig. 17-31). Held in this manner, the torch is much easier to control and move along a line.

It is a good plan to use a metal container under the cutting torch to catch the sparks and hot slag and keep them from flying about the shop.

Cutting cast iron Cast iron is more difficult to cut than steel, and different methods are required. Use excess-acetylene preheating flames, usually about 2X to 2½X, and an oxygen pressure of from 25 percent

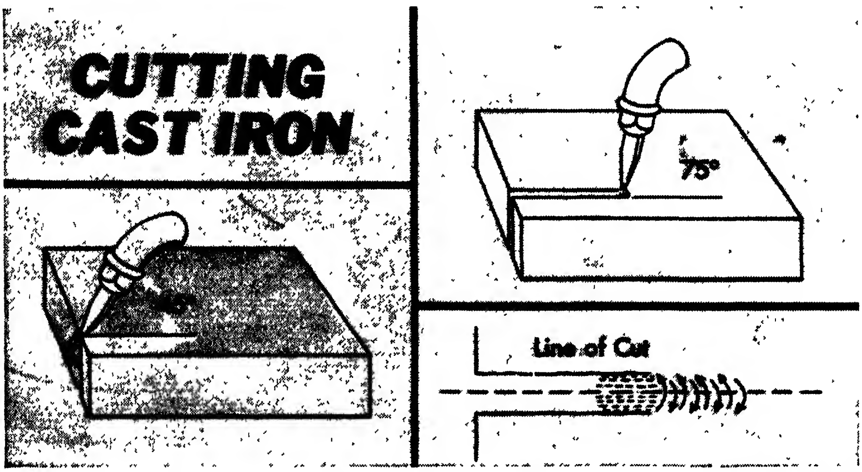


Fig. 17-32. In cutting cast iron, adjust the preheat flames to strongly excess acetylene, lean the tip backward at the top, and preheat almost to the melting point. Then open the cutting oxygen valve, gradually straighten the nozzle up to about 75 deg, and move the torch gradually forward with a short side-swinging motion.

more to double that required for cutting steel. (Use pressures recommended by the maker of the torch if available.)

To start a cut, preheat the edge of the casting at the point to be cut, and then heat the top, leaning the tip backward at an angle of about 45 deg with the surface. Move the nozzle back and forth in short

curves across the line of cutting. When an area about ½ in. in diameter is heated to the melting point, open the cutting-oxygen valve and start the cut. After the cut is all the way through, gradually straighten the nozzle up to about 75 deg (see Fig. 17-32) and move the torch gradually forward. Continue to swing the tip from side to side in short curves across the line of cutting.

JOBS AND PROJECTS

1. Examine and study carefully an oxyacetylene welding outfit, and make sure you understand just how to regulate, adjust, and control it. Make free use of the operator's instruction manuals as well as this chapter.

2. Practice lighting and adjusting the torch, being especially careful to avoid accidents or fires. Also, be sure to use approved methods in turning out the torch and leaving the equipment.

3. Select suitable-size tips and make practice welds on small pieces or on scrap materials. After your welds are completed, bend them, or break or cut them, so that they may be inspected for any flaws or weaknesses. Make other practice welds and see if you can improve your work.

4. Make plans, including lists of materials, for several small appliances that you need and that involve fusion or braze welding. Assemble your materials and make several appliances, carefully observing the principles of good welding to ensure good work.

5. Inspect several farm machines or implements or other pieces of farm equipment for broken or worn parts that can be repaired by fusion or braze welding. Remove them or repair them in place, whichever may be most practical.

6. Hard-face the cutting edges of a plowshare or a set of cultivator shovels or sweeps.

18 REPAIRING AND RECONDITIONING MACHINERY

A COMPLETE treatment of the subject of repairing and reconditioning farm machinery is somewhat beyond the scope of this book. Therefore, only a few of the more important and more common activities in this field will be considered here. Repairing machinery, however, involves many of the basic operations treated in the preceding sections of this book, particularly those on metalwork and welding.

1. REMOVING WORN OR BROKEN MACHINE PARTS

Removing parts of machines generally involves the unscrewing of nuts and bolts, and sometimes also the removal of other fastenings, such as rivets, cotter keys, and setscrews.

Using wrenches Nuts and bolts can be removed from many parts of common machines with ordinary adjustable wrenches (Fig. 18-1*A*),

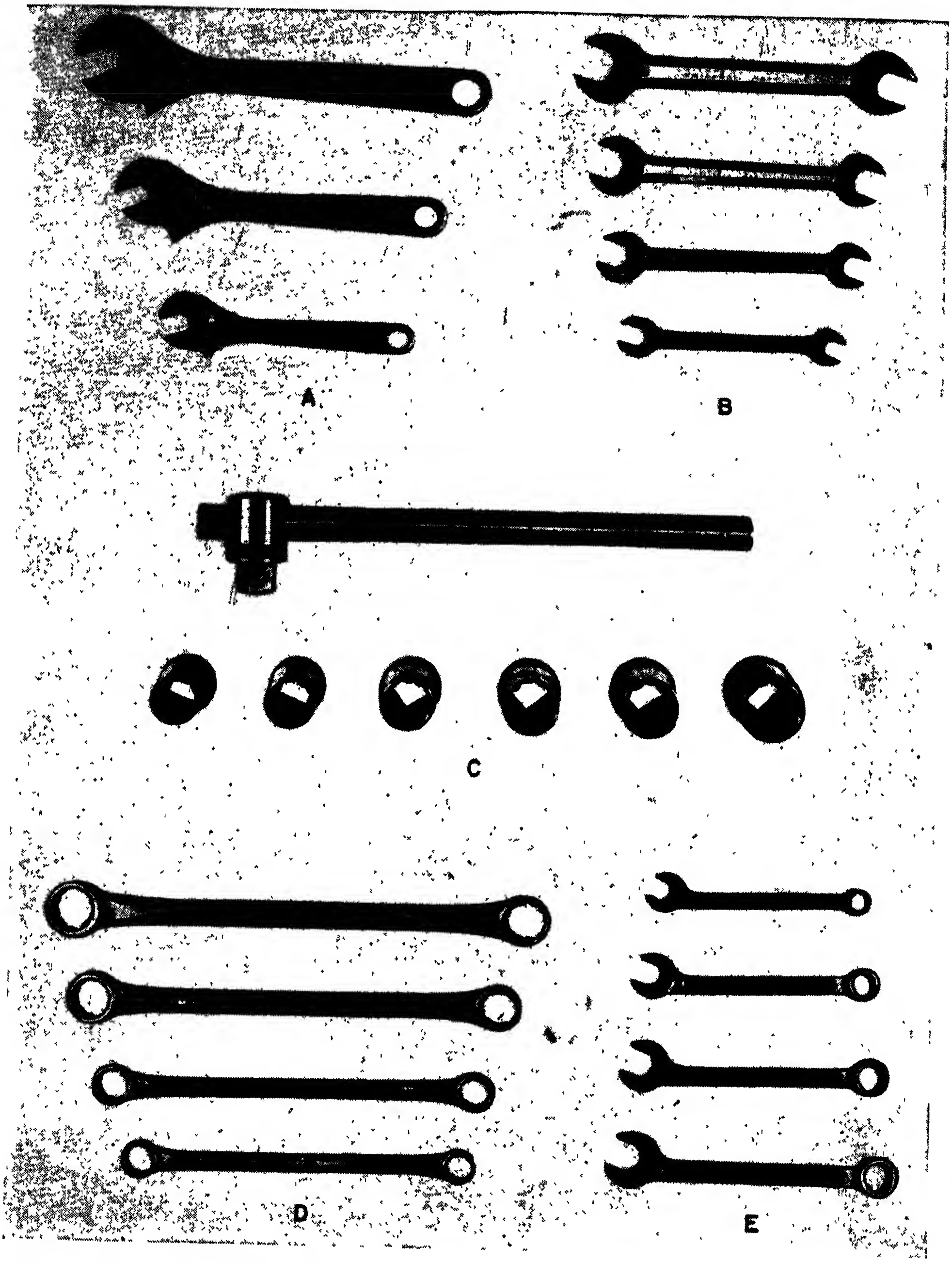


Fig. 18-1. Good types of wrenches for the farm shop: *A*, adjustable wrenches; *B*, open-end wrenches; *C*, socket wrenches; *D*, box-end wrenches; *E*, combination open-end and box-end wrenches.

or with open-end wrenches (Fig. 18-1*B*). In close quarters, however, it may be necessary to use socket wrenches (Fig. 18-1*C*) or box-end wrenches (Fig. 18-1*D*). Where considerable machinery is to be kept in adjustment, a few good open-end, box-end, and socket wrenches will prove to be a profitable investment.

Always use a wrench that exactly fits the nut or bolt. Loose-fitting wrenches are liable to slip and round the corners of the nut or bolt. Also, there is danger of skinning or bruising the hands.

When using an adjustable wrench, always adjust it to fit the nut or bolt tightly, and put it on the nut or bolt so that the pull or push will be toward the open end of the jaws (see Fig. 18-2). Pulling this way lessens the danger of slippage and also the danger of overstraining or springing the jaws of the wrench.

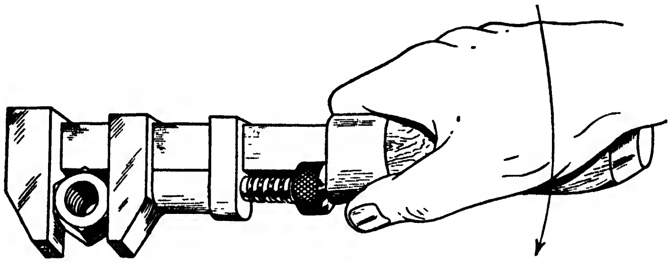


Fig. 18-2. Always adjust an adjustable wrench to fit tightly and always pull (or push) toward the open end of the jaws.

Do not use pliers on nuts or bolts, except possibly as a last resort. It is difficult to get a tight grip with pliers, and they will mar the parts and make it difficult or impossible later to use wrenches. Using pliers on brass nuts and fittings is especially bad.

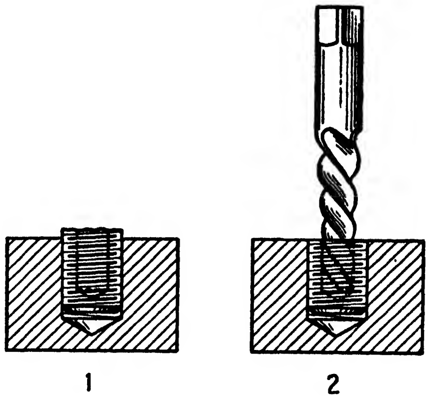
Removing a rusted nut Sometimes, because of rust, it is impossible to turn a nut by ordinary methods. In many such cases, it is best simply to cut the nut off with a sharp cold chisel or a hack saw or cutting torch and to use a new nut and bolt for replacement. Applying penetrating oil or kerosene will sometimes help in loosening a rusted nut. Heating with a blowtorch or a welding torch is also often helpful.

Extracting broken screws and bolts The extraction of broken screws or bolts often requires very painstaking work. If the bolt or screw is not screwed too tightly into place and if a portion of it protrudes, it

may be removed with pliers or a small pipe wrench. If it is tightly in place with a small portion protruding, say ⅛ to ¼ in., it may be feasible to saw a slot across the top with a hack saw and then remove it with a screw driver. Alternate heating and cooling will sometimes loosen a tight screw. Heating may be done with a gasoline blowtorch or a welding torch, and cooling can be done by applying water.

A very satisfactory way of removing large broken screws and bolts is to drill a hole somewhat smaller than the diameter of the bolt, down through the center of the bolt, and then to use a broken-bolt or screw-plug extractor, commonly called an "ezy out" (see Fig. 18-3). Such an extractor might be described as a tapered tool with coarse left-hand threads on the pointed end. To use it, simply start it into the drilled

Fig. 18-3. Steps in removing a broken screw or stud bolt with a screw extractor. 1. Drill a hole in the broken screw. 2. Insert a screw extractor, turning it to the left.



hole, turning it to the left. It wedges itself tightly in the hole, and continued turning will ordinarily loosen the broken bolt and unscrew it.

Another good way of removing a broken bolt, where welding equipment is available, is to butt-weld a short piece of rod or nut onto the end of the broken bolt, and then remove it with a wrench.

2. REPAIRING AND ADJUSTING THE CUTTING PARTS OF A MOWER

Heavy draft, ragged cutting, and excessive wear and breakage can often be avoided by a few simple adjustments and replacement of parts of the cutting mechanism of a mower.

Replacing knife sections To remove a broken or worn knife or sickle section, support the knife rib or bar firmly and strike the back

of the section one or two sharp blows with a hammer. A good way to support the knife is to clamp it loosely in a vise, pointed end of the sections down (see Fig. 18-4).

After the broken section is removed, punch the sheared rivets from the holes in the knife bar, being careful not to enlarge the holes. Then put the new section in place, insert the rivets, and rivet them down.

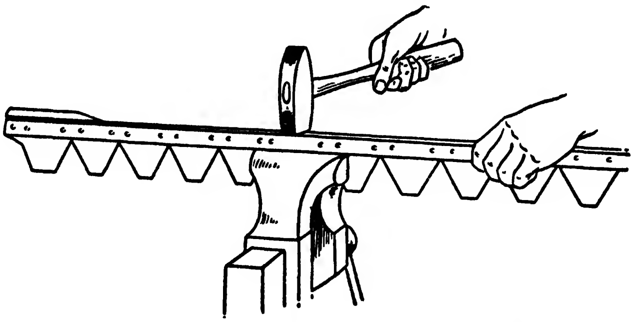


Fig. 18-4. Removing a worn or broken knife section.

Strike one or two heavy blows first to swell the rivets, and then form the heads by light peening with the ball peen of the hammer, or with a rivet set.

Sharpening a mower knife A dull or improperly ground knife causes ragged cutting, rapid wear, and extremely heavy draft. Three points are very important in grinding a knife:

1. Maintain the original width of bevel (see Fig. 18-5). A narrow, blunt bevel does not cut easily; and a wide, keen bevel nicks easily.
2. Maintain the original angle of shear, or the angle between the cutting edge of the section and the guard plate. Otherwise, the grass will tend to slip away and not be cut.
3. Do not overheat and draw the temper.

Mower knives can best be sharpened on special grinders or grinding wheels made for that purpose (see Figs. 18-6 and 18-7). With such a grinder, it is easy to maintain the original bevel and angle of shear. With a little practice and patience, however, mower knives can be ground satisfactorily on regular grinding wheels. Grinding may be done on either the flat vertical side or on the regular curved grinding surface. Motor-driven grinders are much faster and require less work than hand- or foot-operated grinders.

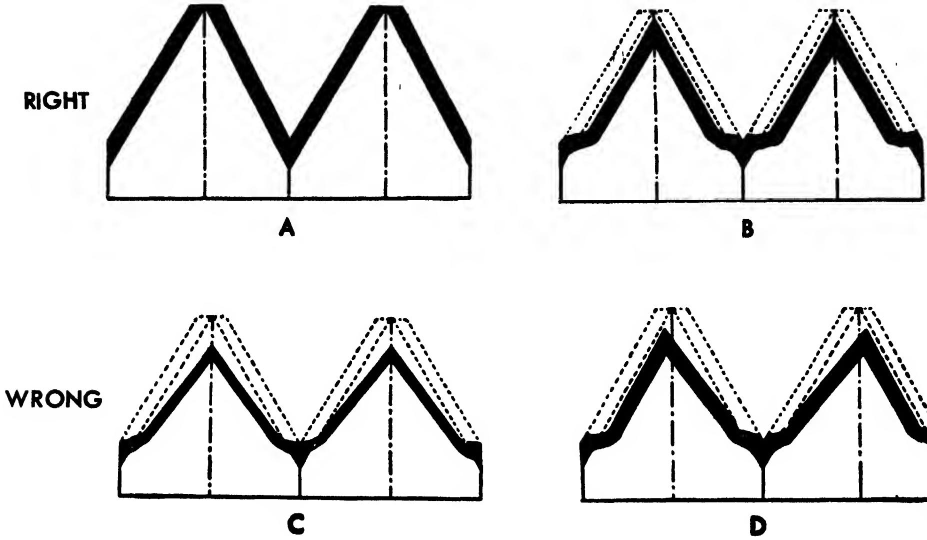


Fig. 18-5. Right and wrong ways to grind mower knives. Dotted lines show outlines of new sections. *A*, new sections with proper width of bevel and angle are retained. *B*, sections properly ground. Proper width of bevel and angle of shear are retained. C, sections improperly ground. The bevels are too narrow, and the angle of shear is wrong. *D*, proper width of bevel, but improper angle of shear. (Deere and Company)

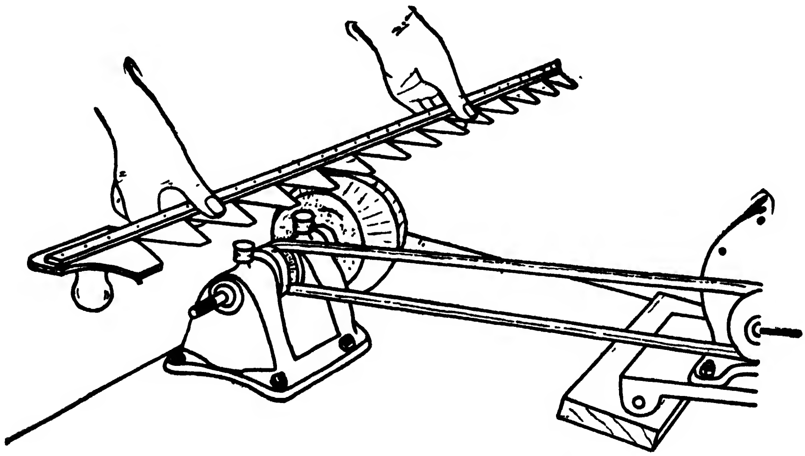


Fig. 18-6. Mower sickles are ground most easily on special grinders made for that purpose, although they can be satisfactorily sharpened on an ordinary grinding wheel.

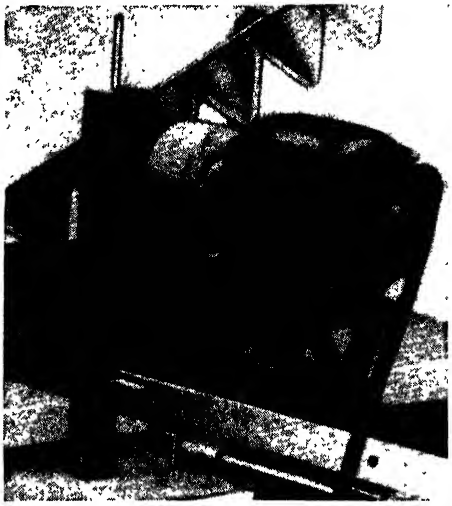


Fig. 18-7. Two types of mower-knife grinders. (Deere and Company)

Straightening a mower knife If a knife bar is bent, either edgeways or flatwise, it will bind as it works back and forth in the cutter bar and cause both rapid wear and increased draft. To straighten a knife, sight along the knife bar to locate the bend. Then place it on some straight surface, as a bench top or mower tongue, with the bend or bulge up, and strike it with a hammer (see Fig. 18-8). Sight again and hammer more as may be required. Be sure to check the knife bar for bends both edgeways and flatwise.

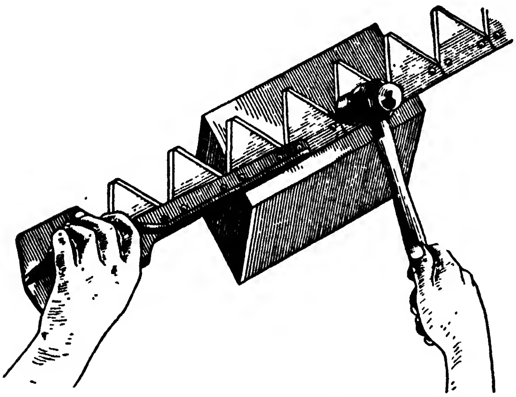


Fig. 18-8. A bent knife may be straightened by hammering it over a straight surface. (Deere and Company)

Replacing guard plates A guard plate, also called *ledger plate,* serves as one blade of the shears and should be kept in good cutting condition just the same as the knife section. When guard plates become worn and dull or nicked or broken, remove them and install new ones.

Guard plates may be removed with the guards either on or off the cutter bar. To remove a guard plate, firmly support the guard from beneath. A special guard-repair anvil (see Fig. 18-9) is excellent for this purpose. Drive the guard rivet down from the top, using a stout

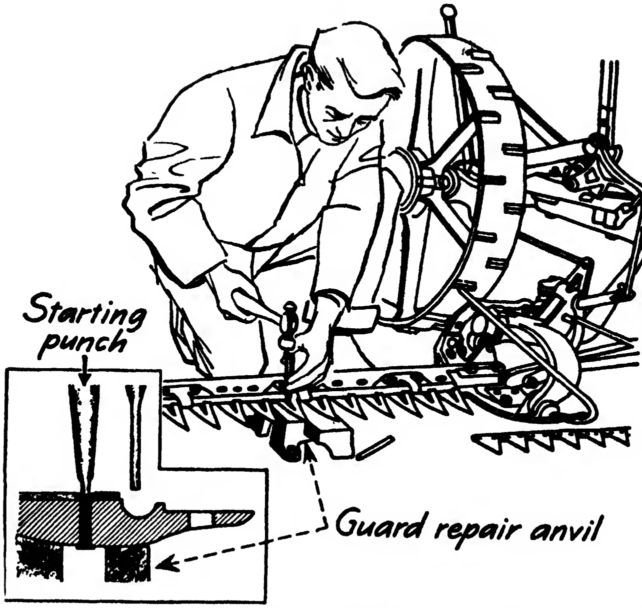


Fig. 18-9. Worn or broken guard plates may be removed without taking the guards off the cutter bar. Start to remove the rivets with a stout starting punch and then finish with a slim punch.

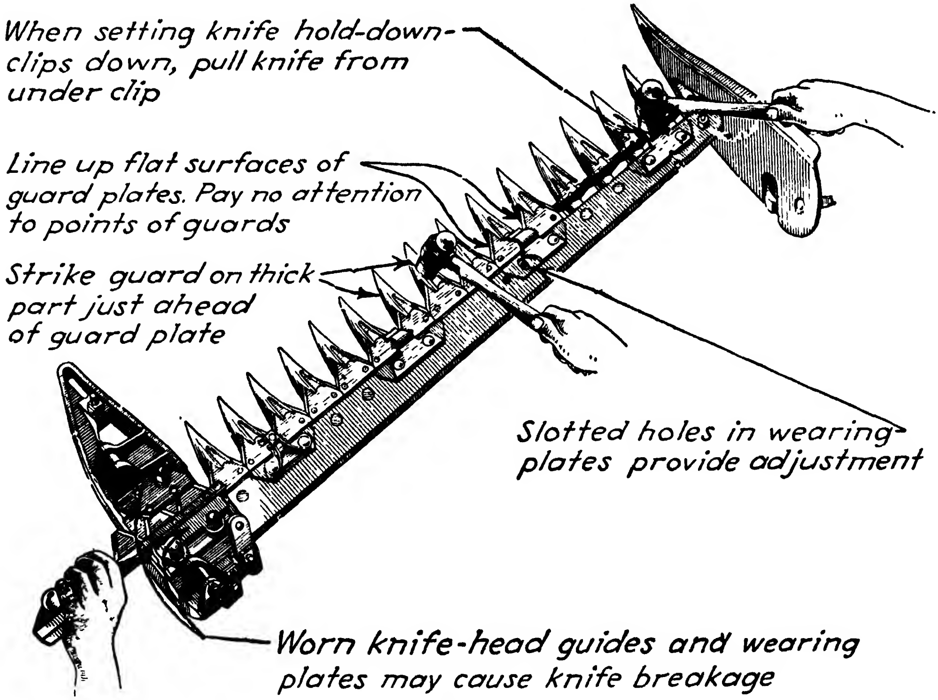


Fig. 18-10. Alignment of guards and adjustment of wearing plates and knife hold-down clips are important for clean cutting and light draft.

punch to start the rivet and a slim punch to finish removing it. Then insert a new guard plate and rivet, and securely brad the end of the rivet. If there is any part of the rivet projecting above the guard plate, trim it off smooth with a sharp cold chisel. New rivets may be inserted from the bottom or from the top of the guard.

Guards should be aligned frequently, for they often strike stones, sticks, or other obstructions and become bent. Even a nearly new mower is likely to need some guards bent back in line. Probably the best way to align guards is to insert a straight knife and hammer the guards that are out of line, bending them up or down as may be required. Strike on the thick part of the guard just ahead of the guard plate. Pound the high ones down first, and then bring the low ones up (see Fig. 18-10). Be sure the guard bolts are tight, and remember in hammering to make the guard *plates* line up. It is not important if the points are somewhat out of line.

Adjusting other cutter bar parts The cutter bar is the heavy steel bar to which guards and other parts are attached. It should not be confused with the knife bar, which is the small bar or rib to which sickle sections are riveted.

The parts of the cutter bar form a sort of groove or trough in which the knife works back and forth. Not only should the knife be straight, but these parts on the cutter bar should be aligned and form a straight place in which the knife can work. Also, they should be adjusted to fit the knife. They should not fit too tightly and therefore bind. Neither should they fit too loosely and allow the knife to bounce or flop about. The knife sections and the guard plates should fit together snugly and form sharp shearing edges, just the same as the two blades of a pair of scissors should fit together reasonably tight (see Fig. 18-11).

The knife hold-down clips should almost but not quite touch the knife when it is resting on the guard plates. To adjust the clips, simply hammer them up or down, but be sure the knife is not in place under a clip when it is being hammered down (see Fig. 18-10). When a *thin* piece of tin can be just slipped under the clip, it may be considered in good adjustment.

The wearing plates, which support the back edge of the knife, are replaceable. When they become worn, replace them with new ones. Always adjust new wearing plates so that their front edges just touch the back of the knife bar. The wearing plates are held in place with

guard bolts, and the holes through which the bolts go are slotted. It is therefore a simple matter to loosen the bolts and adjust the plates forward or backward until they all line up.

Worn knife-head guides are a common cause of knife breakage, as well as poor cutting near the inner end of the knife. These parts should therefore be adjusted or replaced whenever looseness develops.

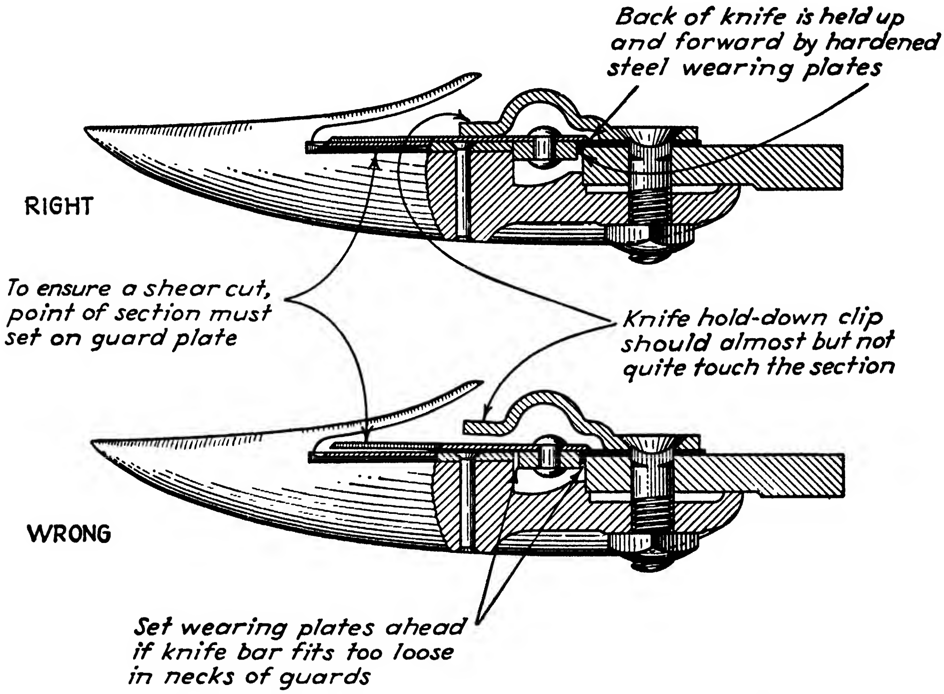


Fig. 18-11. Right and wrong adjustments of hold-down clips and wearing plates.

It is important that all guards and other cutter-bar parts be kept tight. Tight-fitting, strong wrenches, such as socket wrenches, are best for tightening cutter-bar bolts.

•

Aligning a cutter bar A cutter bar is in proper alignment if (1) the pitman is square with, or at a right angle to, the pitman drive shaft, and (2) the pitman pushes and pulls straight on the sickle (see Fig. 18-12).

To offset the backward strain when cutting and to make the pitman and knife run straight, the cutter bar is given a certain amount of lead. That is, when the mower is standing still, the outer end of the cutter

bar is slightly ahead of the inner end. The proper amount of lead is about ¼ in. per ft of cut.

To check the pitman angle, place a square or other straight edge against the front face of the pitman wheel. If the pitman is parallel to the edge of the square, it is square with the pitman drive shaft. To change or adjust the pitman angle on a horse-drawn mower, adjust the tie rod in front of the pitman or the diagonal push bar behind it so as to move the inner shoe of the cutter bar forward or backward as

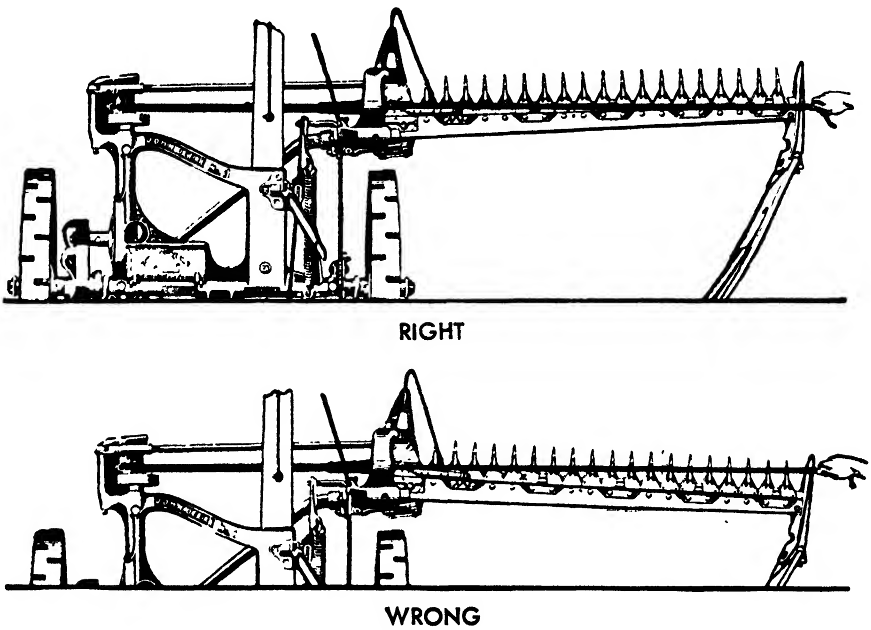


Fig. 18-12. The outer end of the cutter bar should have "lead" to offset backward strain when cutting and to make the pitman and knife run straight. (Deere and Company)

may be needed. This adjustment will also affect the register of the knife. Therefore, check the register (see page 566) before making this adjustment. If some parts have been sprung and thus allow misalignment of the pitman with the pitman drive shaft, these parts may have to be straightened or replaced.

To check the lead of a cutter bar, place the mower on level ground, block the wheels, raise the end of the tongue 32 in. from the ground, and pull the outer end of the cutter bar back as far as it will go. Then tie a string to the pitman head, stretch it loosely over the center of the pitman, over the center of the knife head, and straight on out to the

end of the cutter bar (see Fig. 18-12). Note how the back edge of the knife (not the cutter bar) lines up with the string at the inner end and the outer end of the knife.

An eccentric bushing is provided on *some* mowers for adjusting cutter-bar alignment (see Fig. 18-13). On many mowers no adjustment is provided. On these mowers, and also frequently on mowers having an eccentric bushing, it will be necessary to determine just what causes the lag in the cutter bar, and then remove the cause. In many cases,

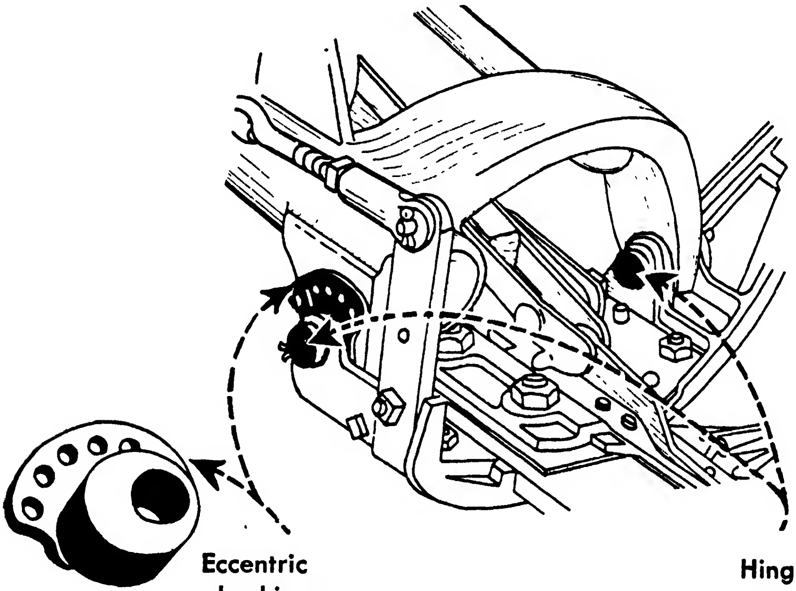


Fig. 18-13. Adjustment for cutter-bar lead. An eccentric bushing is provided on the rear hinge pin of some mowers. Lead on other mowers may generally be restored by taking up play at the hinge pins or otherwise removing the cause of the lag.

it is wear on the hinge pins of the inner shoe (see Fig. 18-14). New hinge pins may need to be installed, or possibly the holes drilled oversize and oversize pins installed. Sometimes parts of the mower have been sprung, and these must be straightened or replaced. Another cause of misalignment is worn bolt holes and bolts that fasten the cutter bar to the inner shoe. In such a case, the bar and inner shoe may be welded in proper position.

Lengthening the diagonal push bar behind the pitman or shortening the tie bar in front of the pitman is not satisfactory for restoring lead. Neither of these adjustments will improve the angle between the pitman

and the sickle. Furthermore, they will change the angle between the pitman and the pitman drive shaft.

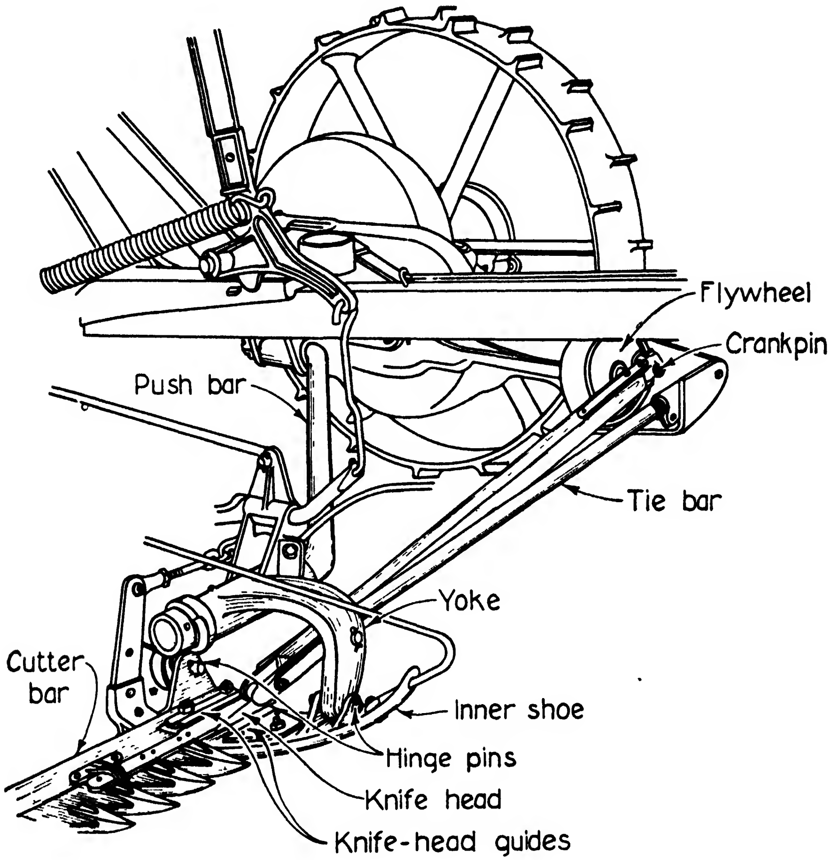


Fig. 18-14. Names of mower parts.

Adjusting knife register By register of the knife is meant the centering of the knife sections in the guards at the ends of the knife strokes (see Fig. 18-15). If the knife does not register, the mower will do an uneven job of cutting, it will choke easily, and the draft will be heavy. If a knife is out of register, first check to be sure that the pitman straps are properly tightened and that there is not excessive play in the bearings at the ends of the pitman. Then if the knife is still out of register, move the whole cutter bar in or out as may be necessary. To do this, shorten or lengthen the tie bar in front of the pitman, and also move the back of the inner shoe yoke in or out on the diagonal push bar the same amount. Various methods are provided for adjust-

Fig. 18-15. Knife sections should register or center in the guards at the ends of the pitman strokes. (Deere and Company)

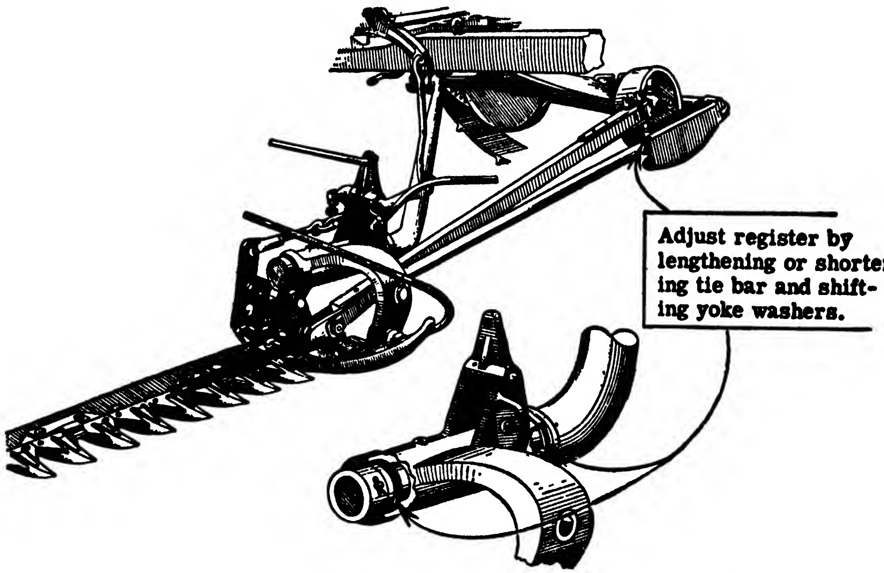


Fig. 18-16. A typical method of adjusting register. Similar methods are provided on other models of mowers. (Deere and Company)

ing the position of the yoke on the diagonal push bar. On some mowers, washers may be shifted (see Fig. 18-16); on others, screw threads are provided; and on other mowers, still other methods are used.

3. REPAIRING AND ADJUSTING SPROCKET CHAINS

Chains and sprockets are used in many places on farm machines for transmitting power. One common type of chain is made of links

that hook into each other. These links are of malleable iron or of pressed steel (Fig. 18-17). In another type of chain, known as the *pintle* chain (Fig. 18-18), the links are fastened together by pins or rivets. *Roller* chains (Fig. 18-19) are commonly used for heavy-duty applications. Such chains have steel rollers working over steel pins that fasten the links together.

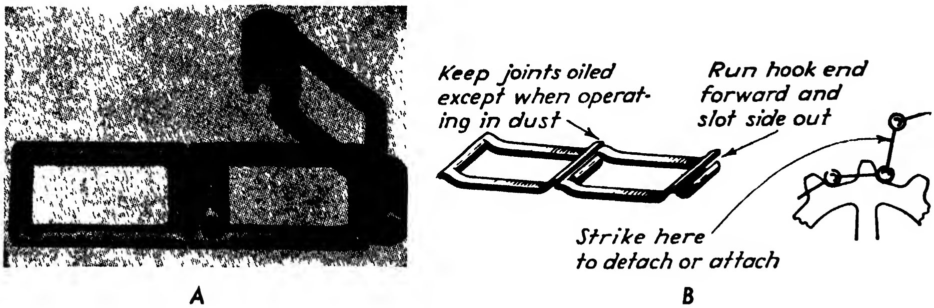


Fig. 18-17. A, Malleable iron-link chain; B, steel-link chain.

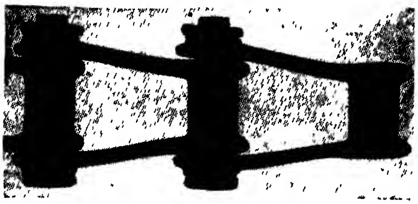


Fig. 18-18. Pintle-link chain.

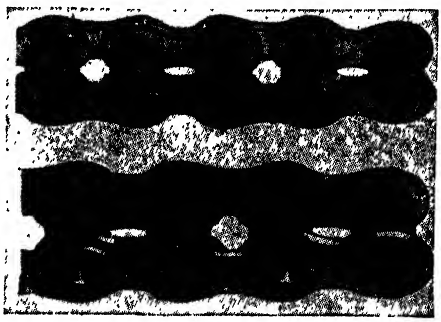


Fig. 18-19. Two types of steel-roller chain.

The sprocket wheels over which a chain runs should be kept in alignment. Tighteners of some sort are commonly provided, and these should be kept in adjustment (see Fig. 18-20). Chains should not be stretched too tight, yet they should not be so loose as to jump off or ride up on the sprocket teeth.

Chain links sometimes break and must be replaced. Hook-link chains are taken apart and hooked together as indicated in Fig. 18-17. When such chains are reinstalled on the sprockets, be sure to put them on *with the open part of the links* away from the sprockets and *with the hooked ends of the links* leading in the direction of travel.

When a chain becomes badly worn and must be replaced, it is almost certain that one or more of the sprockets will need replacing also. In fact, it is often a worn sprocket that causes the chain to wear

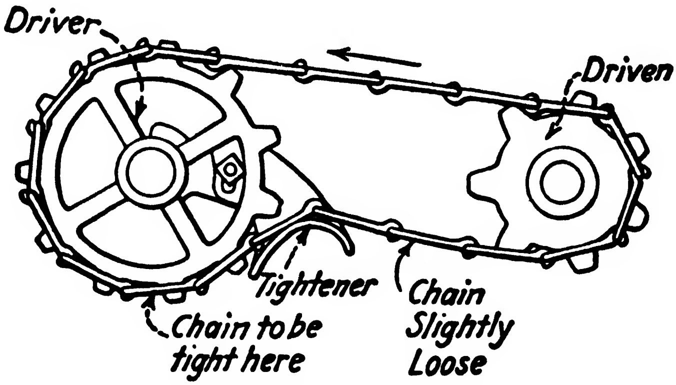


Fig. 18-20. The proper method of running a hook-link chain on sprockets.

rapidly, and if only the chain is replaced, it will soon be ruined and have to be replaced again.

Keep sprocket chains oiled except when operating in dirt and dust.

4. SHARPENING PLOWSHARES

Three different kinds of plowshares are in common use, soft-center-steel shares, crucible- or solid-steel shares, and chilled-iron shares. The methods of sharpening and hardening are different for the different kinds of material. The sharpening of steel shares in the forge is rather heavy work, although otherwise it is not so difficult.

Sharpening steel shares Steel plowshares are sharpened by heating in the forge and drawing the edge by hammering. To heat a share, place it flat in the forge with the cutting edge over the center of the fire. Be careful to heat only a width of about two inches along the edge, and to heat at one time only as much as can be hammered out before it cools below a good working temperature. Do not place the share in a vertical position with the edge down in the fire, as this will heat too much of the share and may cause warping.

Sharpen and shape the point of the share first. Heat it to a cherry red and upset it and bend it to give it the desired down and side suction as indicated in the following paragraph. After the point is sharpened,

work back toward the heel, heating and hammering only a small section at a time. Hammer on top of the share and be careful not to dent it with hammer marks more than necessary (see Fig. 18-21).

It is important for a plow to have suction, both downward and sideward (see Figs. 18-22 and 18-23). The proper amount of suction will depend upon the type of plow and upon the soil condition. Down suction should usually be about 1/4 to 1/2 in. measured at the place shown in Fig. 18-22; and the side suction should usually be about 1/4 in. measured at the place shown in Fig. 18-23. On most plows the suction is obtained by bending the point down and sideways the desired amount at the time of sharpening. On other plows the mounting of the plow bottom on the plow beam is such that the suction will be correct without bending the point.

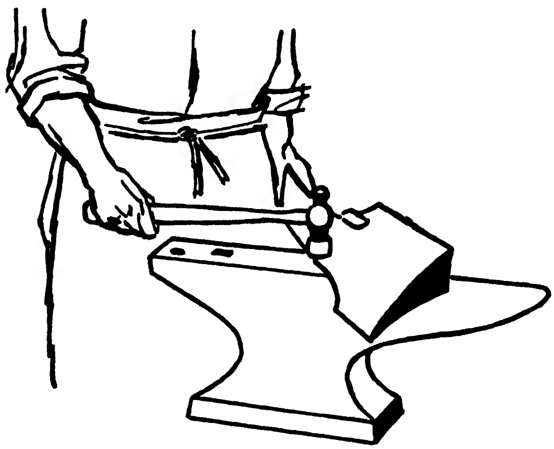


Fig. 18-21. To sharpen a steel plowshare, heat to a cherry red and hammer on top. Heat and hammer only a small section at a time.

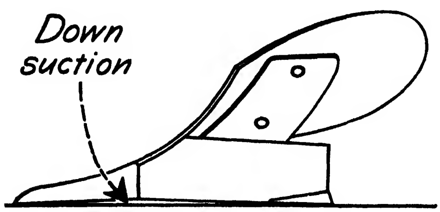


Fig. 18-22. Plows must have down suction to secure penetration. The clearance at the point indicated should be about 1/4 to 1/2 in.

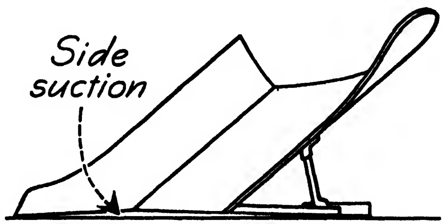


Fig. 18-23. Side suction enables a plow to cut an even, full-width furrow. The clearance at the point indicated should be about 1/4 in.

In the case of a walking plow, shape the outer corner or wing of the share so that a small flat surface bears on the ground and helps to support the outer side of the plow. Sulky and tractor plows require little or no flat bearing surface at the wing of the shares, as the plow wheels furnish the stabilizing support needed.

Hardening soft-center-steel shares A soft-center-steel share may be hardened by heating a strip about 2 in. wide along the cutting edge to a uniform cherry red and then dipping it in clean, cold water, cutting edge down. Solid- or crucible-steel shares should be hardened very little if at all. Hardening makes them brittle and therefore subject to breakage.

Hard-surfacing steel shares Different kinds of extremely hard and long-wearing material, such as Stellite, can be applied to the points and cutting edges of steel shares by means of the oxyacetylene welding torch. Such a material will greatly increase the life of a share, and when carefully applied, its use is generally quite satisfactory. For information on the process of hard surfacing, see Chap. 17, "Oxyacetylene Welding and Cutting," page 547.

Sharpening chilled-iron shares Chilled-iron shares cannot be forged, owing to the nature of the iron. They must be sharpened by grinding or chipping on the top side. Chilled-iron shares are moderate in cost, and it is generally considered best to discard them when they become badly worn and dull.

5. SHARPENING HARROW TEETH

Spike-tooth harrow teeth that have sharp points and sharp edges are much more effective than teeth that have become blunt and rounded from long use. To sharpen harrow teeth, remove them from the harrow and forge them at a red heat. Some harrow teeth may be effectively hardened and tempered, and others not, depending upon the kind of steel of which they are made. It is well to experiment on one or two teeth before hardening a whole set. It may be possible to get them too hard, making them brittle and subject to breakage in use. See Chap. 14, "Farm Blacksmithing," pages 455 to 459 on hardening and tempering tool steel.

6. SHARPENING AND ADJUSTING ENSILAGE-CUTTER KNIVES

To sharpen ensilage-cutter knives, grind them on a grinding wheel. Be careful to grind at the original bevel and with only moderate

pressure to avoid drawing the temper. If there are large nicks, they may be best removed by placing the knife on the work rest and moving it back and forth with the cutting edge square against the revolving wheel. After removing the nicks, grind the edge at the desired bevel.

If considerable grinding of ensilage-cutter knives is to be done, it may be worth while to build a small platform in front of the grinding wheel to serve as a work rest. A small strip may be nailed to the platform to make it easy to place the knife against the wheel at just the right angle.

When the knives are put back on the cutter, be sure to adjust them carefully and bolt them on securely. Adjust the knives to just clear the shear bar. After considerable use, the shear bar itself will have become rounded and should be replaced or turned over to present a new square edge.

7. SHARPENING DISKS AND COULTERS

Many implement-repair shops have special equipment for grinding or sharpening disks and coulters, and it is often advisable to have such

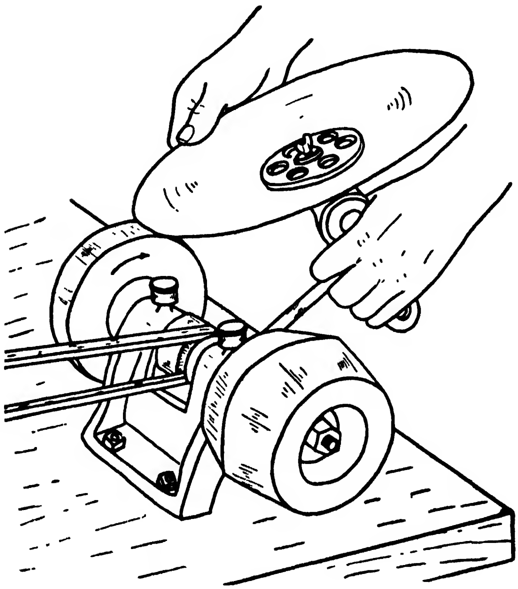


Fig. 18-24. Disks and coulters may be ground on ordinary grinders. Attachments to hold the disks in place are helpful.

work done by one of these shops. A farmer may grind his own disks and coulters, however, if he has the time and if he has a moderately heavy-

duty grinder. Grinding is greatly facilitated by some sort of support that holds the disk in place against the grinding wheel (see Figs. 18-24 and 18-25). Such supports can be made easily in the farm shop.

An excellent way to grind coulters is illustrated in Fig. 18-25. Adjust the bearing to turn freely, and hold the coulter with the bearing slightly to one side of the grinding wheel. The coulter disk will then

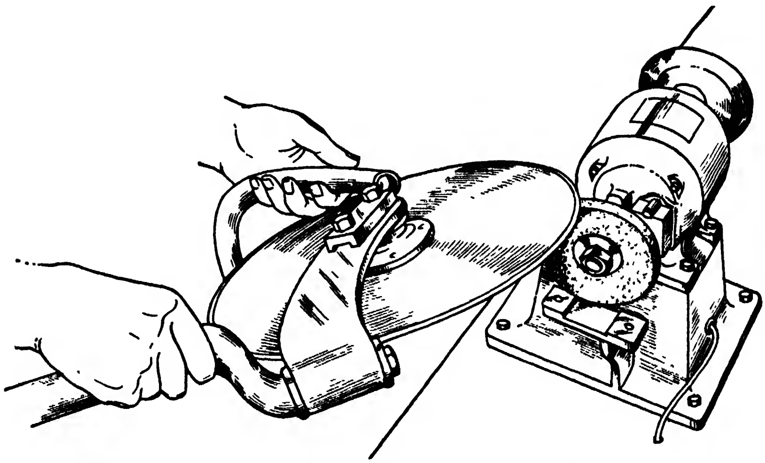


Fig. 18-25. An excellent way to grind a coulter. Adjust the coulter bearing to turn freely and hold the coulter with the bearing slightly to one side of the grinding wheel.

turn as it is being ground, and thus avoid overheating and drawing the temper. The speed with which the coulter turns can be regulated by the distance the bearing is held to one side of the grinding wheel.

8. SHARPENING AND SETTING CULTIVATOR SHOVELS

When cultivator shovels become dull and blunt, they should be sharpened to as near the original shape as possible (see Fig. 18-26). This may be done by grinding or by forging. After considerable use, cultivator shovels will become so worn that they should be repointed or replaced with new ones.

It is not a difficult job to draw out the points and edges of cultivator shovels by forging. Whether or not the shovels should be hardened and tempered after forging will depend upon the kind of steel used in the shovels. If the shovels are of soft-center steel, they may be hardened by heating about 2 in. along the cutting edge to a dull red and then

dipping in water. Solid crucible-steel shovels should be hardened very little if at all. There is danger of breaking them during hardening. Also, it is easy to get them too hard and brittle, which may result in breakage in use.

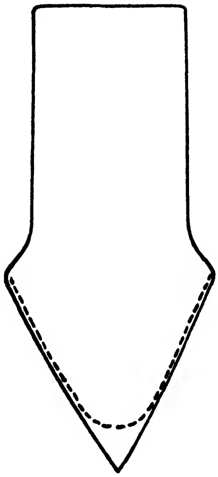


Fig. 18-26. A cultivator shovel. Dotted lines show shape when in need of resharpening. (Deere and Company)

If cultivator shovels are to be sharpened by grinding, grind them on the back or underside.

Cultivators are provided with adjustments to change the angle or pitch of the shovels. If a shovel is set too straight (see Fig. 18-27), it will require considerable pressure to make it penetrate, and there will be a tendency for it to skip and jump. On the other hand, if a shovel is set too flat, the underneath part may be lower than the point, making penetration difficult.

The front shovels may be turned on their shanks to make them throw soil into the row. On some cultivators this will tend to make the gangs spread apart and work away from the row. This tendency may be overcome by turning some of the rear shovels on their shanks opposite to the way the front ones are turned.

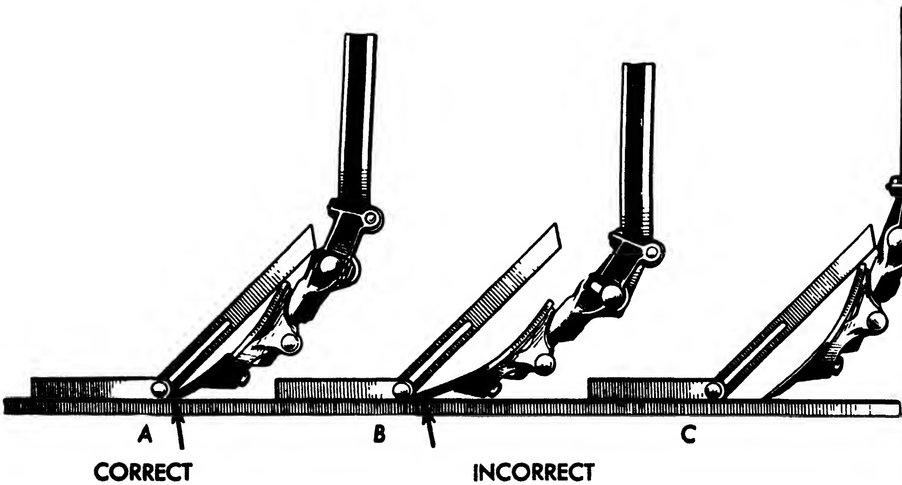


Fig. 18-27. Correct and incorrect adjustments of pitch of cultivator shovels: *A*, correct adjustment; *B*, shovel set too flat, giving poor penetration; C, shovel set too straight, giving poor penetration and uneven operation. (Deere and Company)

9. PROTECTING MACHINERY FROM RUST

In order to avoid lost time and to insure good-quality work when a machine is taken to the field, the bright working parts, such as moldboards, disks, cultivator shovels, and bearings, should be protected against rust.

Used engine oil will prevent rusting for short periods. It may be applied with an old paint or whitewash brush, or with a hand sprayer. If an implement is not to be used for a few days, it is a good plan to oil the polished working parts. When implements are not to be used for long periods, heavy oils or greases should be applied. Special anti-rust greases or compounds are particularly good. Bearings should be well lubricated when machines are put away to avoid rusting while in storage or out of use.

Metal parts of implements and machines, other than wearing surfaces, should be kept painted to avoid rusting. See Chap. 6, "Painting, Finishing, and Window Glazing," page 193, on painting of metal surfaces.

10. LUBRICATING MACHINERY

Late models of farm machines are generally well protected against dust and dirt, and if they are operated and lubricated in accordance with instructions furnished with them, they may be expected to give long trouble-free service.

To be sure that the right kind of lubricant is used and that no points of lubrication have been overlooked, it is a good plan to consult the instruction book for that particular machine. Most instruction books contain lubrication charts.

Critical points on most new-model farm machines are lubricated by grease forced through fittings by a pressure gun (see Fig. 18-28). Pressure guns provide positive lubrication. On most bearings if a little grease is kept working out around the spindle or shaft, dirt will not enter and there is assurance of adequate lubrication.

Installing pressure-gun fittings on old machines Pressure-gun fittings may be installed on old machines where lubrication was originally provided by squirt can or hard oil cups. This is certainly advisable where such machines are to be used much. Where old hard oil cups were used,

this is easily done. Simply unscrew the old cups, and screw in the new fittings. Bushings or reducers may be required in some cases.

To install pressure-gun fittings in plain oil holes used for squirt-can lubrication, either of two methods may be used. Special drive-type fittings may be obtained in some cases and installed by simply driving

Fig. 18-28. Pressure grease guns are used to provide positive lubrication to many parts of farm machines.

or wedging them into the old oil holes. In other cases, the old oil holes may be drilled and tapped with suitable threads (⅛- or ¼-in. pipe threads) and the new fittings screwed in. Grease-gun fittings and accessories are available through implement dealers and automobile supply houses.

JOBS AND PROJECTS

Do several repair jobs on farm machines and implements, working on equipment from your own farm if possible. The following list is suggestive.

1. Replace worn or broken sections in a mower knife.
2. Sharpen a mower knife. Straighten it if it is bent.
3. Replace guard plates on a mower.
4. Align and adjust cutter-bar parts on a mower.

5. Align a cutter bar and adjust knife register on a mower.
6. Repair and adjust the sprocket chains on a corn picker.
7. Sharpen a plowshare.
8. Sharpen a set of harrow teeth.
9. Sharpen the disks and repair a disk harrow.
10. Repair a cultivator and sharpen and adjust the shovels.
11. Install pressure-gun fittings on a machine or implement.
12. Completely overhaul and paint an implement, such as a mower, grain drill, corn planter, or manure spreader.

19 MAINTAINING ELECTRICAL EQUIPMENT

1. Splicing Electric Wires
2. Attaching Wires to Terminals
3. Repairing Electric Cords
4. Replacing Fuses
5. Protecting Electric Motors against Overload
6. Cleaning and Lubricating Electric Motors
7. Rigging a Small Portable Electric Motor
8. Figuring Pulley Sizes and Speeds
9. Connecting Dry Cells
10. Charging a Storage Battery
11. Making Extensions to a Wiring System
12. Installing a Doorbell, Buzzer, or Chimes
13. Installing an Electric Fence

ELECTRICAL equipment has come to be quite important on the modern farm, and while it is reasonably trouble-free and foolproof, a certain amount of repair and maintenance work is necessary for best results. A complete treatment of the subject of farm electrical equipment is beyond the scope of this book, but some of the more important and more common activities in this field are discussed in this chapter.

1. SPLICING ELECTRIC WIRES

Poor splices are a source of trouble and danger. If they are not mechanically strong, they may loosen or pull apart. If they do not

make good electrical contact, there will be a drop of voltage, causing poor operation of appliances on the circuit; and the joints or splices will heat, possibly creating a fire hazard.

There are four main steps in making a splice: (1) removing the insulation and cleaning the wires; (2) twisting or fastening the wires together; (3) soldering the joint; and (4) insulating the splice by covering it first with rubber tape and then with friction tape.

Removing insulation To remove insulation from a wire, cut it off with a knife or crush it with a pair of pliers and then strip it off. If it is

small wires

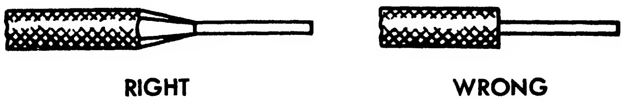


Fig. 19-1. In cutting insulation from a wire, hold the knife at an angle as in sharpening a pencil. Be careful not to nick the wire.

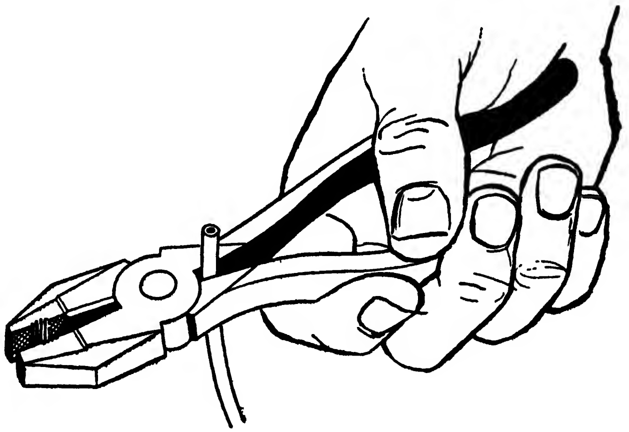


Fig. 19-2. Crushing the insulation with pliers and then stripping it off is generally easier than cutting it off with a knife.

to be cut off with a knife, be careful not to nick the wire. Cut at an angle as in sharpening a pencil (see Fig. 19-1).

If suitable pliers, such as electrician's pliers, are available, crushing and then stripping off the insulation will usually be quicker and easier than cutting with a knife. Crush the insulation with the heel of the pliers (see Fig. 19-2), and then strip it off. Next scrape the wires clean, using the back of a knife or some blunt-edged tool.

Making the common splice To make the common splice, also called the *Western Union splice,* remove the insulation for about 4 in. on the end of each wire. Then place the wires together and hold them firmly as shown in Fig. 19-3*A*. Make five or six turns with one wire in one direction and five or six turns with the other wire in the other direction (see Fig. 19-3*B* and *C*). Then cut the ends off short and smooth them

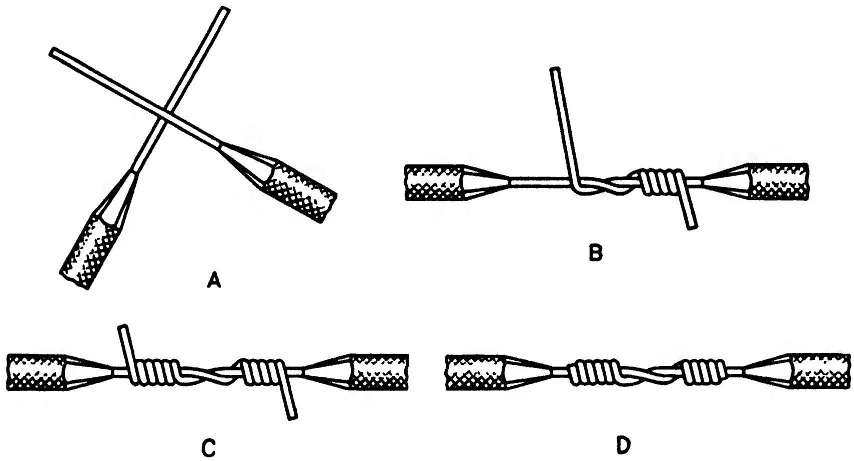


Fig. 19-3. Steps in making the common, or Western Union, splice.

down with pliers to prevent damage to insulation which must be wrapped over the splice later.

Soldering the splice After the wires are cleaned and wrapped tightly together, apply a noncorrosive soldering flux, such as rosin or a noncorrosive paste, and then solder the splice. Under no conditions should acid be used as a flux. In soldering the splice, it is important that the wires themselves be heated hot enough to melt solder thoroughly. Be sure the solder penetrates into all the spaces between and around the wraps of the splice, and does not simply coat over the outside of the splice (see Fig. 19-4). (For further information on soldering, see Chap. 11, "Soldering and Sheet-metal Work," pages 327 to 349.)

Insulating the splice After the splice is soldered, wrap it with tape. A common practice is to wrap it first with rubber tape and then with friction tape. Another method is to use a newer type of insulating scotch tape, which requires no outer wrapping of friction tape.

In wrapping a splice with rubber tape, start on the tapered rubber

insulation of one wire at one end of the splice, and wrap spirally toward the other end, keeping some tension on the tape and making the wraps overlap. When the end of the splice is reached, wrap back toward the first end in the same manner. Wrap back and forth two or three times, and be sure that the rubber tape covers all parts of the splice where the outer braid has been removed. Then wrap at least two layers of friction tape over the rubber tape.

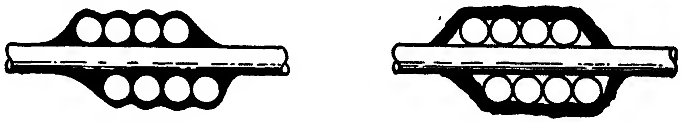


Fig. 19-4. Solder melted by hot wires flows into all spaces, giving a good joint. Hot solder applied to cold wire results in a poor joint.

If the newer insulating scotch tape is to be used, wrap it in the same manner as for other tapes. Since no outer covering of friction tape is required, it makes a neat, compact splice which is especially good in junction boxes where space is limited.

Splicing duplex or two-conductor cord To splice a two-conductor cord, splice each wire separately, using Western Union splices. Be careful to stagger the splices as shown in Fig. 19-5. Staggering minimizes

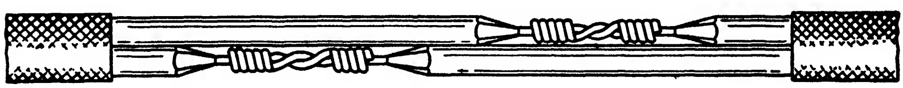


Fig. 19-5. To splice a two-conductor cord, splice each wire separately, staggering the splices so that they will not be side by side.

the possibilities of short circuits and makes the splice less bulky. Wrap each splice separately with rubber tape, and then wrap friction tape over the whole splice.

Making a tap splice A tap splice is used for joining a branch wire to another wire. To make it, remove about 4 in. of insulation from the end of the tap wire and about 1¼ in. from the main wire. Scrape the wires clean, and wrap the end of the tap wire around the main wire about five or six turns (see Fig. 19-6). Then solder the

splice and insulate it by wrapping it first with rubber tape and then with friction tape.

Where there is likely to be pull or strain on the wires, then it is better to use the *knotted tap splice* (Fig. 19-7).

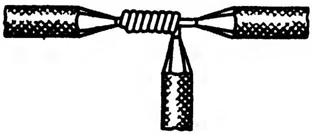


Fig. 19-6. The tap splice is used for joining a branch wire to another wire.

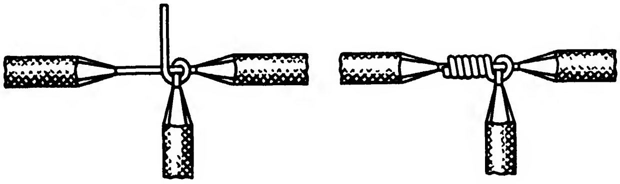


Fig. 19-7. Steps in making a knotted tap splice. Use this kind of tap splice where there will be strain on the wires.

Making a pigtail splice The pigtail splice, also called *rattail splice* (Fig. 19-8), is a quick and easy way to join the ends of wires where there will be no strain on them. It is generally used inside of outlet boxes in house wiring. Like all permanent splices, the pigtail splice should be soldered and then insulated by wrapping with rubber tape and friction tape.

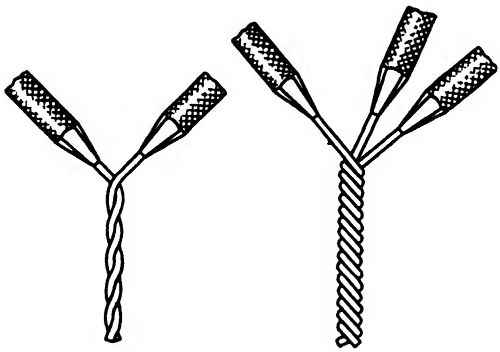


Fig. 19-8. The pigtail splice is used for joining wires where there will be no strain on them.

2. ATTACHING WIRES TO TERMINALS

To attach a wire to a terminal like that shown in Fig. 19-9, first remove the insulation and then bend a hook as shown in Fig. 19-10.

Be sure to place the hook under the screw in such a manner that tightening the screw will tend to close the hook rather than open it. It is important that the hook be formed close to the end of the insulation on the wire (see Fig. 19-11). Small round-nose or long-nose pliers are convenient for forming such hooks.

Soldering lugs (see Fig. 19-12) are sometimes used for attaching large wires, particularly stranded cables, to terminals. To use such a lug,

Fig. 19-9. A type of terminal commonly used for attaching wires.

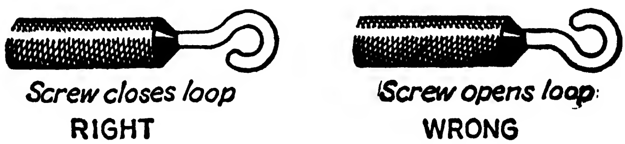


Fig. 19-10. Right and wrong methods of hooking the end of a wire under a terminal screw. As the screw is tightened, it should close the loop, not open it.

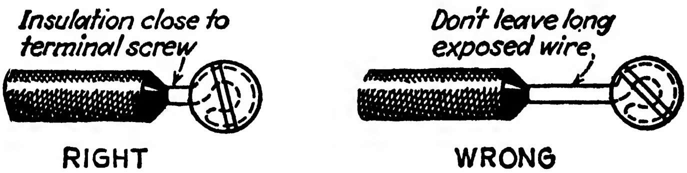


Fig. 19-11. Form the hook close to the end of the insulation to avoid too much bare or exposed wire.

Fig. 19-12. A type of soldering lug commonly used for attaching large wires, particularly stranded wires, to terminals.

the end of the wire is soldered into the hollow end of the lug. This may be difficult unless the work is carefully done. Both the end of the wire and the inside of the lug, if not already tinned (coated with solder), must be cleaned, fluxed, and then tinned. The end of the wire may be tinned by dipping it into a small ladle of molten solder, after it has been cleaned and fluxed. To attach the lug to the wire, melt some solder into the lug, insert the end of the wire, and apply heat. Some additional solder may be required. It is important that the lug be com-

pletely filled. Otherwise, the joint may have high resistance which would cause heating and possibly melting of the solder and loosening of the joint. Be careful not to burn the insulation near the end of the wire.

Using solderless connectors Special approved clamps and connectors that do not require soldering (see Fig. 19-13) are often available for making connections to electrical equipment. They are convenient and easy to use and are often better than splices or lugs that require soldering, particularly if the soldering is not well done.

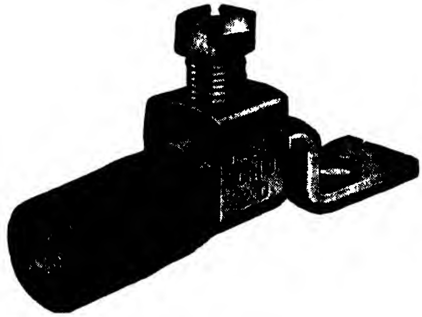


Fig. 19-13. A type of solderless connectors.

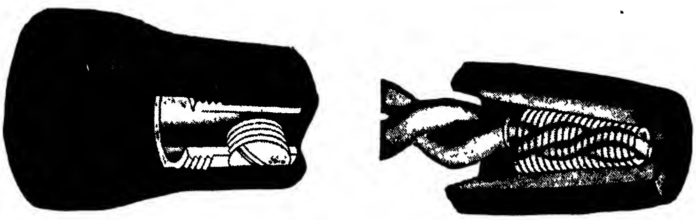


Fig. 19-14. Two types of solderless connectors. (Ideal Industries, Inc.)

Solderless connectors of the type shown in Fig. 19-14 are commonly used for connecting wires where there is no strain on the joint, as in outlet boxes. One type has a brass sleeve with a set screw. To use it, clean the insulation from the ends of the wires, slip them into the sleeve, and tighten the setscrew. Then screw the insulating shell over the brass sleeve. Another type of solderless connector simply screws onto the ends of the wires to be connected. Connectors of this type are made or covered with some sort of insulating material and, therefore, do not have to be covered with tape. They are available in several sizes. Always use a size suitable for the wires being connected.

3. REPAIRING ELECTRIC CORDS

The attachment plugs on the ends of electric cords, like lamp cords, often become broken and need to be replaced. Also, the end of a cord which is attached to the lamp or other appliance sometimes becomes frayed, loose, or broken. Repairs to such cords are easy to make if a few simple rules are observed. In time, electric cords become so frayed and worn, however, that they are not safe to use and should be discarded. Frayed and poorly insulated cords are dangerous, particularly when used near heat registers, radiators, water pipes, or bathroom fixtures. Such cords have caused death from electric shock. Frayed or worn cords may also cause short circuits within themselves and possibly cause fires if the circuits upon which they are used are not properly protected by fuses.

Fig. 19-15. Frayed cords are dangerous, particularly when used near good electrical grounds such as heat or water pipes or bathroom fixtures.

Attaching a plug to a cord Four points are important in attaching a plug to a cord: (1) tie a "holding knot" in the ends of the wires, (2) remove the insulation and clean the ends of the wires back just enough to hook around the terminal screws, (3) wrap the ends of the wires

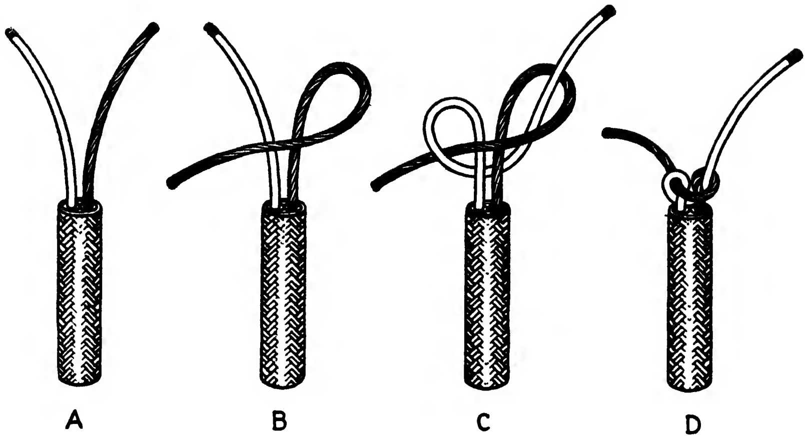


Fig. 19-16. Steps in making the holding, or Underwriters', knot.

around behind the prongs to better withstand pulls on the cord, and (4) place the ends of the wires well under the screwheads and avoid fraying.

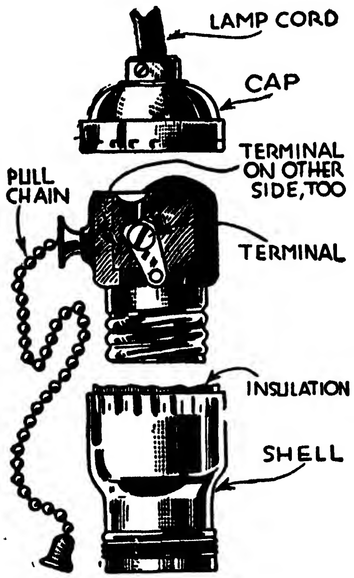


Fig. 19-17. A lamp socket taken apart to show the various parts.

The holding knot, sometimes called the *Underwriters' knot,* is made as indicated in Fig. 19-16. If the knot would be too bulky to be drawn down well inside the attachment plug, it may be omitted. If it is not made, however, it is very important that the ends of the cord be wrapped behind the prongs to resist pulls on the cord.

Attaching a lamp socket to a cord To attach a lamp socket to a cord, first remove the cap from the socket, usually by pressing at a point indicated on the socket shell and then prying. Then insert the end of the cord through the cap, tie the holding knot, remove the insulation from the ends of the wires and attach them to the terminal screws in the same manner as attaching a plug (see Fig. 19-17). Be sure to leave no loose frayed ends of the wire. It is important that the insulating bushing in the top of the cap, and the insulation inside the shell, be in place and in good condition.

4. REPLACING FUSES

A fuse is a protective device used to limit the current that may flow in a circuit. It consists essentially of a short length of metal wire or ribbon of low melting temperature, enclosed in a suitable plug or cartridge. The size of fuse wire or link in a fuse is such that it will carry a given current continuously, but will melt or "blow" if a larger current flows. When a fuse blows, it opens the circuit and stops the flow

Fig. 19-18. Before replacing a blown fuse in an older-type fuse box with exposed current-carrying parts, stand on dry footing and open the main switch if it is accessible. (General Electric Company)

of current. A fuse is therefore a safety device, and the importance of using fuses of the proper size cannot be overemphasized.

In case an oversize fuse is installed, currents larger than the safe capacity of the wires may flow, overheating the wires, and possibly causing fires. In new wiring installations, nontamperable fuses are required according to the National Electrical Code.[1] A nontamperable fuse prevents the use of a larger-size fuse once a fuse of the proper size has been installed. In older wiring systems, nothing prevents one from

[1] The National Electrical Code is a set of regulations governing the installation of electric wiring and electrical equipment. It is issued by the National Board of Fire Underwriters.

using any size of fuse up to 30 amp, since all plug fuses up to this size are interchangeable.

A blown or burned-out plug fuse can usually be identified by a smoked or smudged window in the cover. Before replacing a blown fuse, in an older-style fuse box with exposed current-carrying parts, open the main switch if it is near and is easily accessible. This eliminates the possibility of shock. On newer-style fuse boxes, only the tops of the fuse plugs themselves are exposed. In such boxes, the fuses may be replaced without danger of shock if one is at all careful. In opening or closing power-line switches, stand on dry footing in order to avoid the possibility of shock.

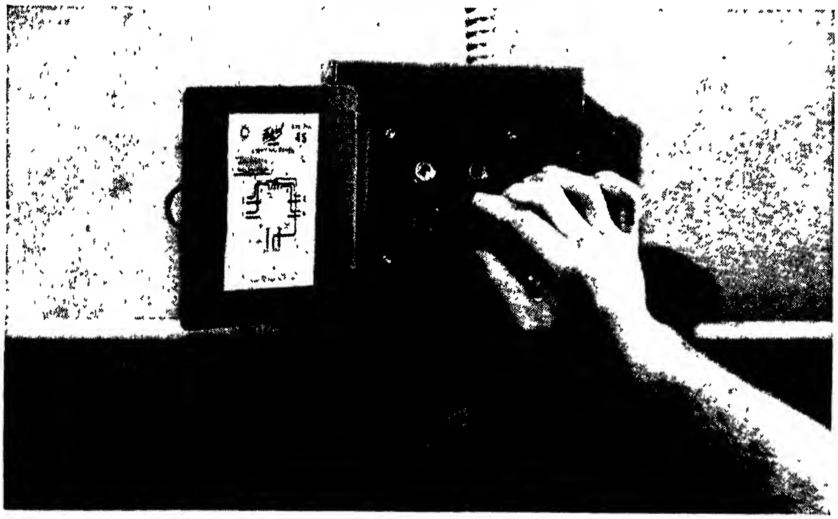


Fig. 19-19. In replacing a fuse, always use one of the proper size. Do not use oversize fuses, and do not place pennies or foil behind blown fuses.

Before replacing a blown fuse, first determine, if at all possible, what caused it to blow, and remove the cause or remedy the trouble. In replacing a fuse, always use one of the proper size, usually 15 amp for ordinary house-wiring circuits. Do not use oversize fuses, and never put pennies or foil behind blown fuses.

5. PROTECTING ELECTRIC MOTORS AGAINST OVERLOAD

Electric motors cannot be protected by ordinary fuses. A motor draws a much higher current while starting than it does after it is

started and operating under normal load. A fuse that would allow the starting current to flow would also allow a much higher than normal full-load current to flow. Thus a motor might become overloaded and burn out without burning out the fuse.

A motor should be protected by a time-lag fuse or by a thermal-overload protective device. A time-lag fuse (see Fig. 19-20) allows considerably higher than normal current to flow momentarily while the motor is starting, but would open the circuit in case of an overload lasting more than a few minutes. Such a fuse should be placed at or near the motor, so that only the current supplying the motor flows through it. It would not do to place the time-lag fuse in the fuse box supplying two motors or one motor and other appliances.

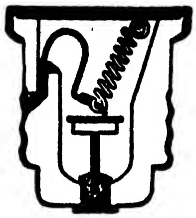


Fig. 19-20. A time-lag type of fuse which will carry temporary overloads without blowing.

The time-lag fuse shown in Fig. 19-20 has a small pot of solder or other metal which melts at low temperature and through which the current flows. A comparatively large current can flow momentarily without melting this small pot of metal, but if a current even slightly more than normal flows continuously the solder soon melts and thus opens the circuit.

A thermal-overload protective device is commonly attached to the motor or to the starting switch for the motor. It gives the same sort of protection to a motor as a time-lag fuse. It will allow higher than normal currents to flow temporarily, but will trip open the circuit in case of overloads that cause the motor to heat above safe operating temperatures. After a thermal-overload device opens the circuit and the motor cools, the device may be reset and the motor started again.

To install a time-lag fuse in a motor circuit, simply wire a fuse receptacle in the circuit. It is best to have the fuse receptacle inside a metal box. Be sure to use a fuse of a size that is not more than 15 or 20 percent larger than the normal full-load current of the motor, as indicated on the motor name plate.

A thermal-overload protective device to be installed on a motor should likewise be suited in size to the current rating of the motor.

A motor running under full load will soon become quite warm. If one can hold his hand on it for at least 10 sec however (see Fig. 19-21), the motor is not too hot.

6. CLEANING AND LUBRICATING ELECTRIC MOTORS

Motors operating in dusty places often become very dirty and should be cleaned occasionally. Dust and dirt may obstruct the flow of air around and through a motor and cause it to overheat. Also dirt may

Fig. 19-21. Testing a motor for overheating. If the bare hand can be held on the motor for at least 10 sec, it is not too hot. (General Electric Company)

Fig. 19-22. A badly neglected motor. Dust and dirt may obstruct air passages and cause overheating or may get into moving parts and cause undue wear. (General Electric Company)

get in the bearings or on the brushes and cause undue wear. Air from a tire pump, a blower attachment on a vacuum cleaner, or from a compressed air line is very effective in removing dirt from the inside parts of a motor. If the motor is extremely dirty, remove one or both end plates to give better access to the insides (see Figs. 19-23 and 19-24). To remove the end plates, take the nuts off the bolts that hold the plates in place and pry gently and carefully, or jar the end plates with a small hammer and block of wood.

Cleaning the commutator On the end of the armature or rotating part of some motors, there is a commutator. Stationary carbon brushes,

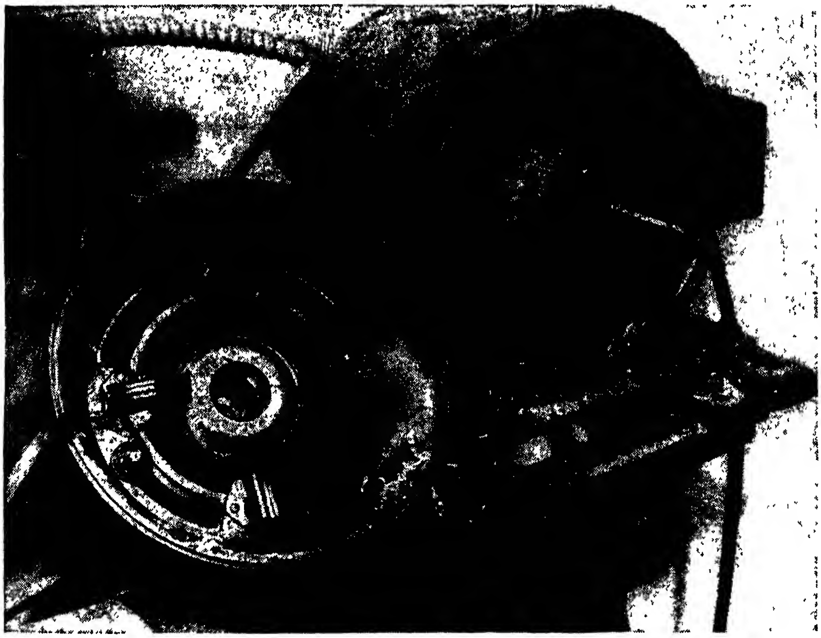


Fig. 19-23. An end plate removed from a dirty motor so that it may be easily and thoroughly cleaned. (General Electric Company)

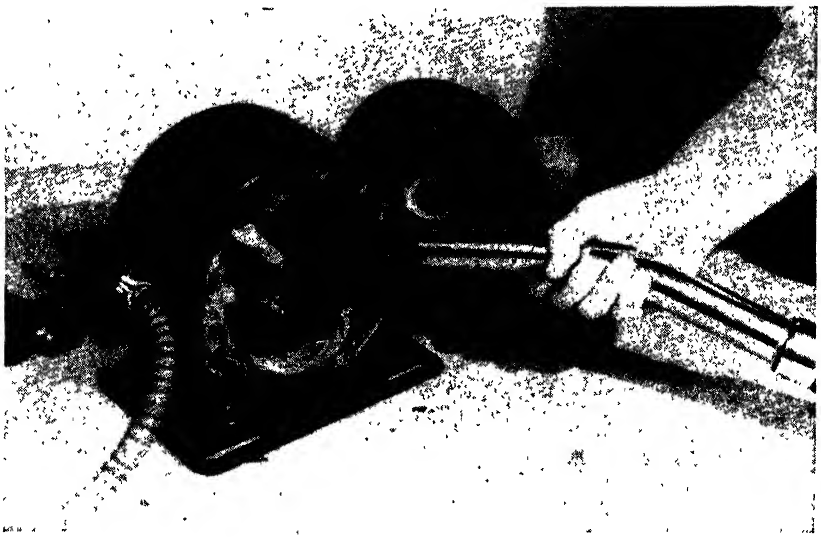


Fig. 19-24. A motor being cleaned by blowing with air under pressure. Both end plates and the rotor have been removed to make thorough cleaning easy. (General Electric Company)

held in brush holders, ride on the commutator, and after long service it becomes dirty. To clean a commutator, fold a piece of fine sandpaper (No. 00) around the end of a thin narrow piece of wood, and hold it against the commutator while the motor is running (see Fig. 19-25).

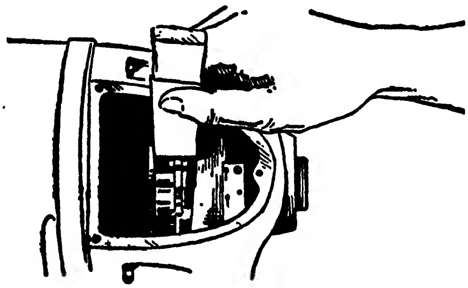


Fig. 19-25. Cleaning a motor commutator. A piece of fine sandpaper (No. 00) is held lightly against the commutator by means of a small piece of wood while the motor is running. (From *Protect Your Electric Motors,* Central Hudson Gas and Electric Corporation)

Do not use emery cloth. Emery is a conductor of electricity and particles may become imbedded between the commutator bars and cause trouble. If the commutator is rough or pitted, or ridged from long use, remove the armature from the motor and take it to a shop equipped to turn the commutator on a lathe.

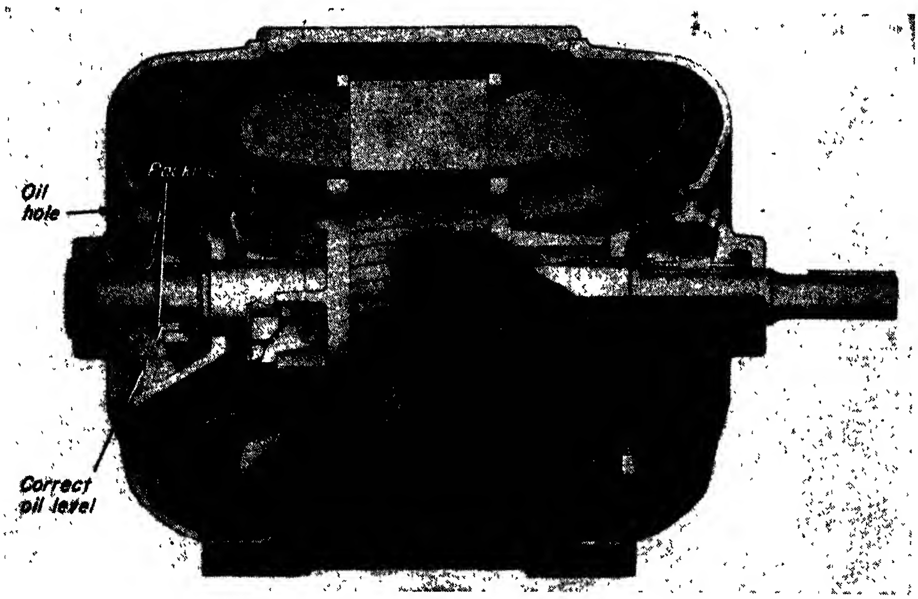


Fig. 19-26. A plain-bearing motor equipped with oil reservoirs packed with waste or yarn. A few drops (not squirts) of oil every few weeks are usually adequate. (General Electric Company)

Oiling a motor The bearings of an electric motor require very little oil. Either overlubricating or underlubricating may cause trouble. Excess oil may work into the windings, causing early deterioration of the insulation and failure of the motor.

Some electric motors are equipped with plain bearings (see Fig. 19-26), and a small oil reservoir is provided at each bearing. A few drops (not squirts) of oil every few weeks in each bearing are usually adequate.

Other motors are equipped with ball bearings that are intended to be cleaned and repacked with a light cup grease or petroleum jelly after long periods of service. Some motors are equipped with ball bearings that were greased and sealed when they were made and that require no further attention.

7. RIGGING A SMALL PORTABLE ELECTRIC MOTOR

A small motor may easily be made portable so that it may be quickly and easily moved from one job to another (see Fig. 19-27). To rig up such a motor, twist together some short pieces of insulated wire to serve

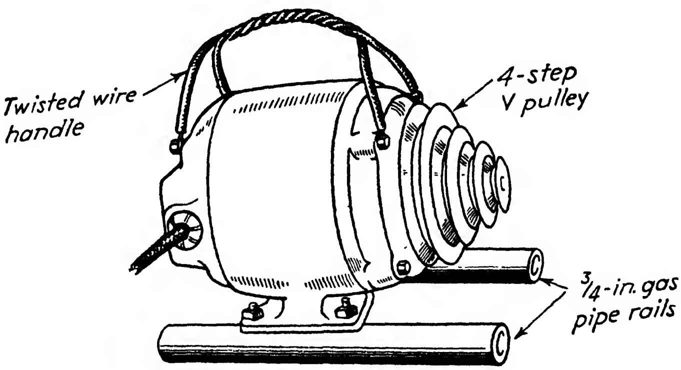


Fig. 19-27. A small portable electric motor.

as a handle and fasten the ends under nuts on the end of the motor. Then drill and bolt short lengths of pipe to the motor base. The motor is then ready to be taken from job to job. To hold the motor in proper position at its various stations, nail or screw narrow cleats to the motor stands or supports (see Fig. 19-28).

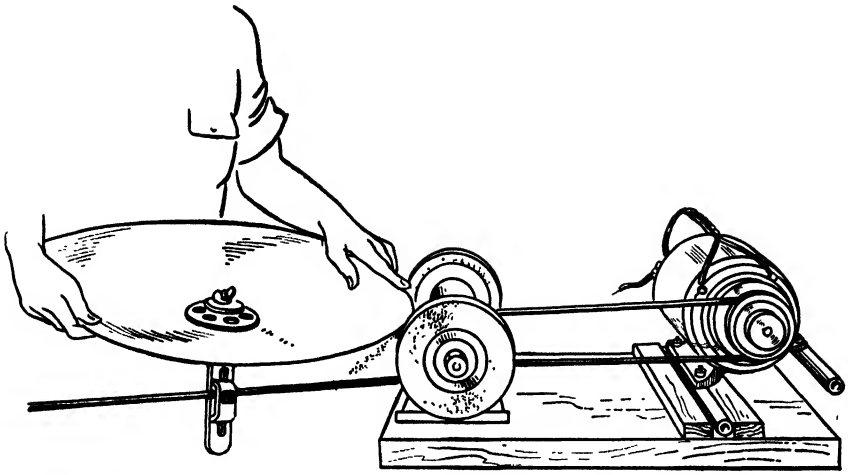


Fig. 19-28. Sharpening a disk with a portable electric motor. Note the cleats on the grinder baseboard which hold the motor in place. Part of the weight of the motor helps keep the belt tight.

8. FIGURING PULLEY SIZES AND SPEEDS

Pulley speeds are designated in revolutions per minute. For most efficient service, a driven machine usually needs to be operated at a definite speed; and since electric motors operate at definite speeds, it is often necessary to figure the size of pulley required on the motor or on the driven machine to give the desired speed.

There are very simple rules for figuring pulley sizes and speeds, but even simple rules are likely to be forgotten or improperly applied unless the principle underlying them is understood. The rules for figuring pulley sizes and speeds are based on one very simple assumption, namely,

If a belt runs over two pulleys, the distance which a point on the rim of one pulley travels in one minute is the same as the distance which a point on the rim of the second pulley travels (assuming no belt slippage).

Stating this simple assumption mathematically, we have

Distance traveled by point 1 = distance traveled by point 2

The distance which a point on the rim of a pulley travels in one minute is equal to the distance around the pulley times the number of revolu-

tions it turns in a minute. The above equation may therefore be stated as

$$\text{circumference of pulley 1} \times \text{rpm of pulley 1} = \text{circumference of pulley 2} \times \text{rpm of pulley 2}$$

Since the circumference of a circle is the diameter $\times$ 3.1416, we may write

$$\text{diam}_1 \times 3.1416 \times \text{rpm}_1 = \text{diam}_2 \times 3.1416 \times \text{rpm}_2$$

Since 3.1416 appears on both sides of the equation, it may be simplified by dividing both sides by 3.1416, giving

$$\text{diam}_1 \times \text{rpm}_1 = \text{diam}_2 \times \text{rpm}_2$$

When any three of the four factors of the equation are known, the fourth is easily found. For example, suppose a motor pulley is 2 in. in diameter and runs 1,725 rpm and it is desired to know the size of pulley required on a driven machine to give a speed of 1,150 rpm. Substituting in the formula and solving,

$$2 \times 1725 = \text{diam}_2 \times 1150$$

$$\text{diam}_2 \times 1150 = 3450$$

$$\text{diam}_2 = \frac{3450}{1150} = 3$$

9. CONNECTING DRY CELLS

Dry cells are often used to operate such appliances as telephones and electric fences. Two to four cells are commonly used, and they are practically always connected in series. To connect cells in series, connect the positive, or center, terminal of one cell to the negative, or outside, terminal of the next (see Fig. 19-29). This leaves a positive con-

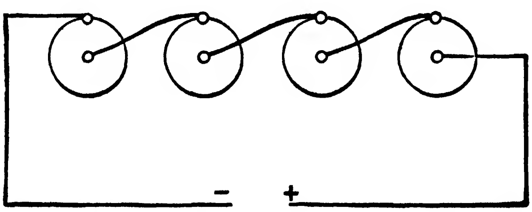


Fig. 19-29. Dry cells connected in series. The positive, or center, terminal of one cell is connected to the negative, or outside, terminal of the next.

nection at one end of the set of cells and a negative connection at the other. Connect these two terminals of the battery to the terminals of the appliance or into the circuit in which it is to be used. If there are instructions on the appliance indicating which terminal is to be connected to the positive side of the battery and which to the negative, be sure to observe them. Make all connections tight.

10. CHARGING A STORAGE BATTERY

The state of charge of a storage battery is best tested with a hydrometer (see Fig. 19-30). The specific gravity of the electrolyte (acid) in a battery varies with its state of charge, and the hydrometer is used to measure specific gravity. When a battery is fully charged, the specific gravity will be 1.250 to 1.300; and when discharged, about 1.100 to 1.150.

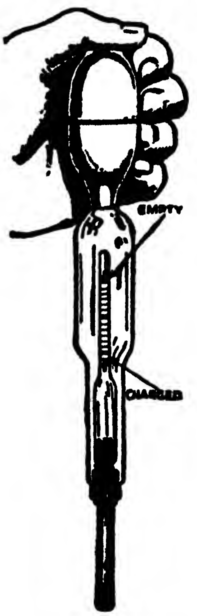


Fig. 19-30. A hydrometer for testing the state of charge of storage batteries.

Storage batteries must be charged by direct current. Alternating current cannot be used without first being rectified. There are on the market different types of battery chargers, however, which operate on alternating current and deliver direct current to a battery. To use such a charger, simply connect it to the storage battery according to directions on the charger and plug it into an a-c outlet.

Another way often used to charge storage batteries is to drive an automobile type of generator with a small gas engine or a ¼ or ⅓ hp electric motor. The generator is then connected to the battery in the same manner as in an automobile or on a tractor. The positive terminal of the generator must be connected to the positive terminal of the battery and the negative terminal of the generator to the negative terminal of the battery. The generator should be equipped with a reverse-current cutout, just the same as an automobile generator, to prevent current from flowing backward from the battery to the generator in case the generator stops running. An automobile type of ammeter should also be connected in the charging circuit to indicate the rate of charge. The charging rate of the generator can be regulated by some method, depending upon the type of generator, but most commonly by shifting the third brush on

the commutator. Usually a small screw or bolt on the end of the generator may be loosened or turned to allow the third brush to be shifted on the commutator. Shifting the brush in the direction of rotation of the armature increases the charging rate. A generator speed of 1,000 to 1,500 rpm is usually satisfactory.

A battery should not be charged at a rate so high that it becomes hot or gases (bubbles) excessively. Batteries may be charged at higher rates when first put on charge than later after they become nearly charged. The maximum charging rate varies with the size of the bat-

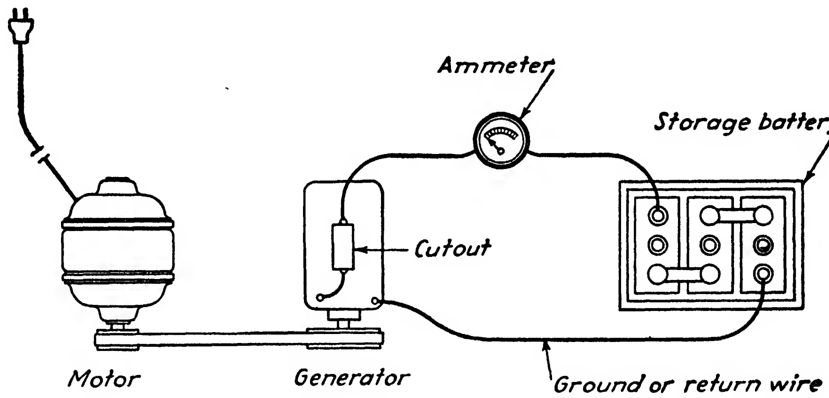


Fig. 19-31. A battery-charging outfit made by driving an automobile-type generator with an electric motor.

tery, but for most 6-volt automobile and tractor batteries, 10 to 15 amp is usually high enough. A longer charging period at a moderate rate is usually better than a higher rate for a shorter period.

Adding water to storage batteries Add water to each cell of a storage battery occasionally to replace that lost by evaporation and that lost owing to the action of the charging current. The charging current decomposes some of the water, forming gases which escape through the vents in the caps on top of the cells.

Only clean water approved by the dealer selling the battery, or distilled water, should be added to a storage battery. Keep battery water in a glass bottle or jug. If approved battery water or distilled water is difficult to get, melted artificial ice or filtered rain water that has not been in contact with metal may be used. A good way to collect rain water is to place an earthenware jar out in the rain after it has been raining about ten minutes.

Do not allow the level of the electrolyte in a storage battery to fall so low as to expose the plates, and do not add too much water. Usually a level about ⅜ in. above the plates is high enough. Adding too much water will cause the cells to overflow when the battery becomes warm and the electrolyte expands. This not only causes a loss of electrolyte, but may cause serious corrosion of battery terminals.

Cleaning corroded terminals If electrolyte is spilled and left on battery terminals, a greenish deposit will form. To stop the action of the electrolyte and to clean the terminals, wash the parts thoroughly with a solution of common baking soda or ammonia. Brushing with a stiff brush is helpful. Then wash with water and wipe dry, and finally apply a light coat of vaseline or cup grease.

11. MAKING EXTENSIONS TO A WIRING SYSTEM

Wiring a building for electric service, or making major extensions or changes to a wiring system, should be done only by an experienced electrician or someone familiar with the regulations of the National Electrical Code. By using extreme care, however, one with less experience may safely make minor extensions, such as installing a convenience outlet, or a lamp to be controlled by a pull chain, or even a lamp to be controlled by a wall switch. If in doubt as to procedures in doing such work, consult a book or manual on wiring or someone experienced in wiring. *Make sure that the electric current is turned off before making any extensions or repairs.*

Using nonmetallic-sheathed cable Nonmetallic-sheathed cable (see Fig. 19-32) is practically always used for inside wiring of farm build-

Fig. 19-32. Nonmetallic-sheathed cable is the type of wiring generally used in farm buildings. (Crescent Insulated Wire & Cable Co.)

ings. It consists of two (or three) insulated wires inside a nonmetallic outer sheath or cover which has been treated to make it moisture- and fire-resistant. The National Electrical Code recommends it for all loca-

tions where an especially good ground connection is not available. It is connected to outlet and junction boxes with suitable connectors built into the boxes or separately attached.

Flexible armored cable was formerly used extensively for wiring of farm buildings. It consists of two (or three) insulated wires inside a flexible, spirally wound, galvanized metal cover. Since it is more expensive and harder to work and install than nonmetallic-sheathed cable, and since it is subject to corrosion when used in barns and in damp places, it is now seldom if ever used in farm wiring.

When electric wires or cables are exposed, as in barns, basements, and attics, they must be properly supported and given protection against mechanical injury. For details of such support and protection when making minor extensions to a wiring system, consult an experienced electrician, a wiring manual, or the National Electrical Code.

Installing an outlet and pull-chain fixture This type of fixture is commonly used in such places as closets, basements, and attics. To install a pull-chain fixture, it will be necessary to run two wires or a two-

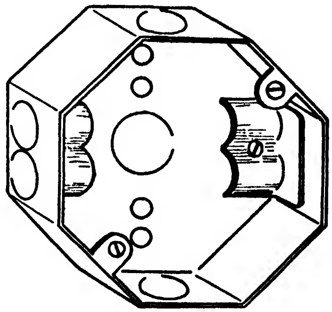


Fig. 19-33. One of many types of meta outlet boxes used in wiring buildings (National Electric Products Corporation

wire cable from a source of current to a metal outlet box (see Fig. 19-33) mounted at the location of the new fixture. This cable must be supported or mounted on the walls or other parts of the building in an approved manner. All connections and splices must be made inside metal outlet boxes. Current may be supplied from a branch circuit already in place, if the addition of this extra outlet does not overload the circuit.

Mount the new outlet box on or in the ceiling or wall at the place selected for the new fixture. Fasten the box securely in place. Then open the main switch or the switch at the fuse and distribution panel; and open a metal outlet box that is near the new outlet and has two

live wires running into it, that is, two wires that come direct from the fuse panel without the interruption of a switch. Then run a two-wire cable from this box to the new box just installed. Fasten the ends of the cable into openings in the boxes with suitable cable connectors, and fasten the cable to walls or other supports in an approved manner. Splice the new wires onto the old ones in the old outlet box, connecting black wire to black and white wire to white. Then connect the wires

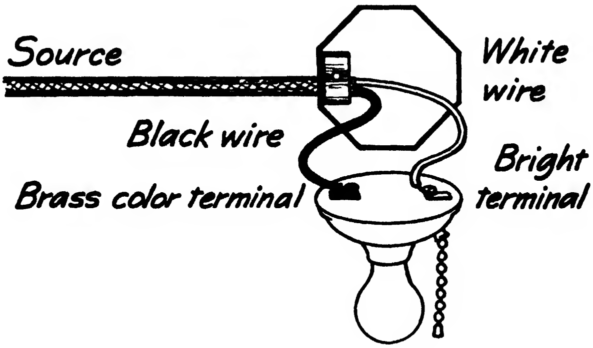


Fig. 19-34. The wiring connections for a pull-chain fixture using armored cable.

at the new box to the terminal screws of the pull-chain fixture, connecting the white wire to the bright screw and the black wire to the brass colored screw (see Fig. 19-34). Finally, attach the fixture to the outlet box, the fixture serving as a cover for the box.

Installing a convenience or appliance outlet To install a convenience or appliance outlet, first mount a metal outlet box in the baseboard or on the wall at the location for the new outlet, and securely

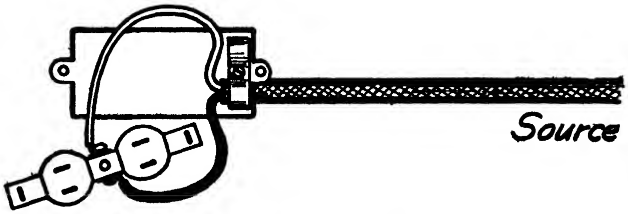


Fig. 19-35. Installing a convenience outlet.

fasten it in place. Then run a two-wire cable from this new box to a suitable source of current, probably another outlet box in the wiring system, and connect the wires in the manner outlined in the preceding paragraph (see Fig. 19-35).

Installing a fixture controlled by a wall switch To install a fixture and a wall switch to control it, mount a metal outlet box for the fixture and also one for the wall switch. Then run a two-wire cable

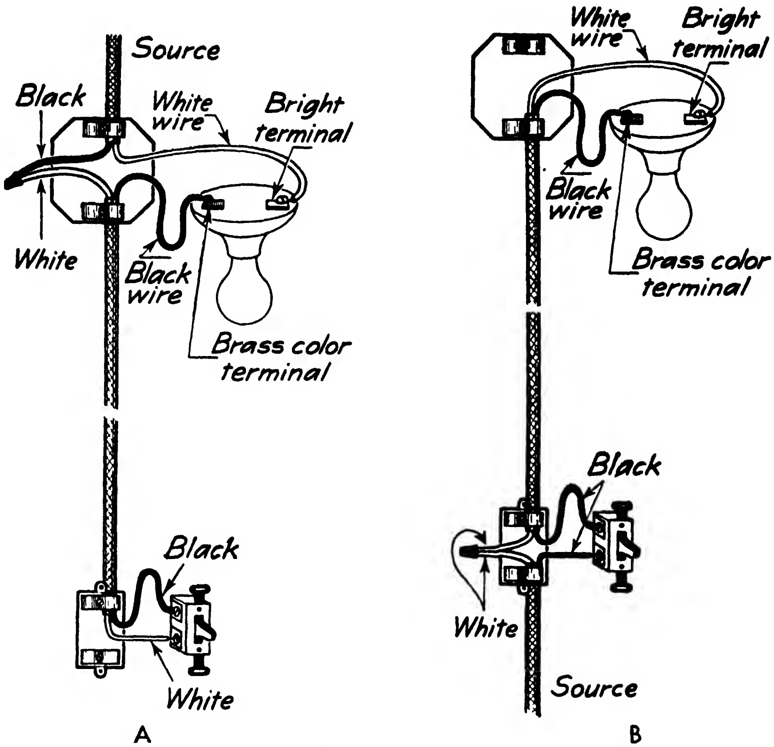


Fig. 19-36. Installing a fixture controlled by a wall switch. A, fixture located between the source and the switch. B, switch located between the source and the fixture.

between these two boxes, and also between the fixture box and a source of current, in the manner outlined for installing a pull-chain fixture. Make the connections as shown in Fig. 19-36.

12. INSTALLING A DOORBELL, BUZZER, OR CHIMES

Current supplied from a low-voltage transformer is commonly used for operating doorbells, buzzers, and chimes. Annunciator wire or bell wire is commonly used to wire bell or buzzer systems. It is fastened to walls or other supports with insulated staples. Since such wires carry only low-voltage current, they do not require as heavy insulation as wires supplying current for lights and 110-volt appliances.

The simplest doorbell system consists of a push button at the door, a bell, and a source of current wired as shown in Fig. 19-37. It is easy, however, to wire the system so that a button at one door rings a bell and a button at a second door rings a buzzer (see Fig. 19-38).

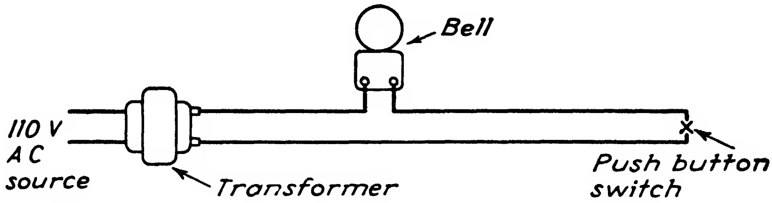


Fig. 19-37. Wiring connections for a doorbell system using a transformer as a source of current.

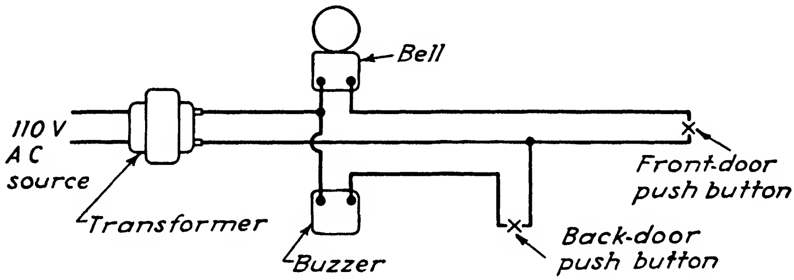


Fig. 19-38. Connections for operating both a bell and a buzzer from the same transformer.

13. INSTALLING AN ELECTRIC FENCE

Electric fences have proved both economical and practical, particularly for temporary fencing. Such a fence is quickly and easily installed and often makes it feasible to utilize certain temporary pastures that might otherwise go to waste. An electric fence consists essentially of one or two fence wires fastened to posts by means of porcelain insulators and connected to a fence charger or controller. The controller is a special unit, operated from a dry-cell or storage battery or from a 110-volt lighting circuit. It may be mounted in the barn or some other building and connected to the fence, or it may be mounted somewhere away from buildings if it is battery-operated. *Use only fence chargers which are approved by the Underwriters' Laboratories or other testing and approving agencies.* Fatal accidents, both to human beings and to animals, have been caused by the use of homemade and other unapproved chargers.

Setting the posts and attaching the wire In building an electric fence, brace the corner posts well, and space the line posts two to three rods apart. Posts may have to be placed closer together in going over uneven ground. Fasten the wire on the posts at a height about three-fourths the height of the animals to be confined within the fence. One

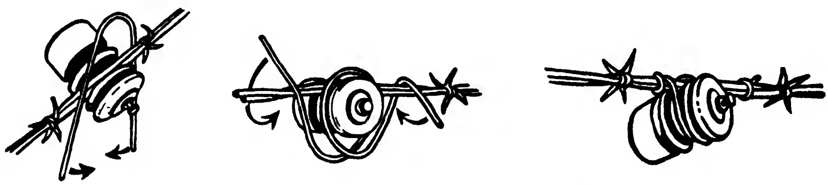


Fig. 19-39. Method of fastening electric-fence wire to insulators on posts. (Prime Manufacturing Company)

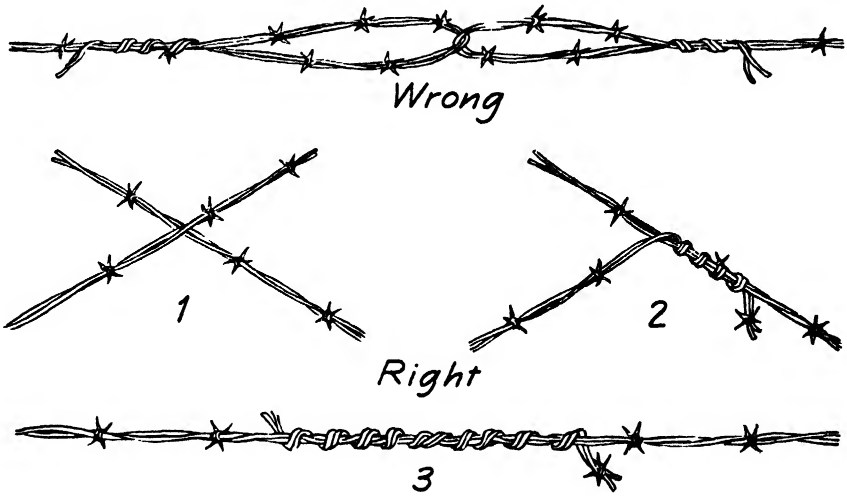


Fig. 19-40. Right and wrong ways to splice electric-fence wire. (Prime Manufacturing Company)

wire 30 to 40 in. above the ground is usually satisfactory for horses and cattle. In the case of hogs of different sizes, two wires are usually better, one about 16 to 18 in. from the ground for the large hogs, and one 6 to 8 in. for the smaller ones.

Stretch the wire tight enough to prevent sagging between the posts, and attach it to insulators on the posts (see Fig. 19-39). On corner and end posts use heavy-duty or strain insulators. Use the Western Union type of splice in splicing the fence wire, so as to ensure a good electrical contact at the joint (see Fig. 19-40).

Gates are easily made as indicated in Fig. 19-41.

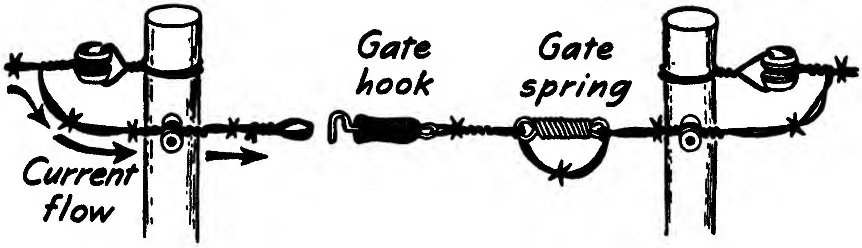


Fig. 19-41. Method of making a gate in an electric fence. (Prime Manufacturing Company)

Connecting the fence unit or controller Mount the fence controller in a place where it will be kept dry and clean, and connect one terminal to the insulated fence, and the other to a ground connection (see Fig. 19-42). It is important that the ground rod or pipe extend down to

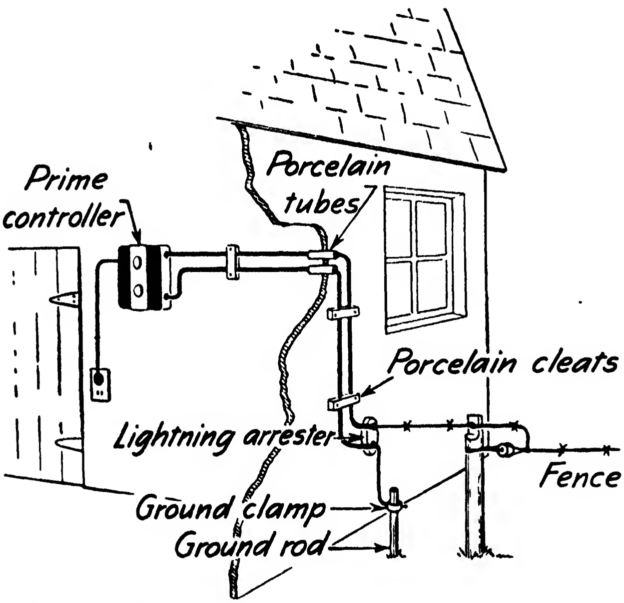


Fig. 19-42. An electric-fence controller located in a barn and connected to the fence. (Prime Manufacturing Company)

permanently damp soil (see Fig. 19-43). Also, connect a lightning arrester between the insulated fence line and the ground rod.

Training livestock to respect an electric fence Always train animals before attempting to confine them with an electric fence. Otherwise, they may not respect it and go right through it. To train the animals, fence off a corner of a feed lot or corral with electric fence, place some

attractive feed just beyond the fence, and allow the animals to come in contact with it a few times. Most animals can be trained in 30 min to an hour. Sheep, being better protected by their wool than most animals, are harder to control and may require a training period of several hours. Ears of corn hung to the training fence with small wires are sometimes used in training animals. If the ground is dry, it may be

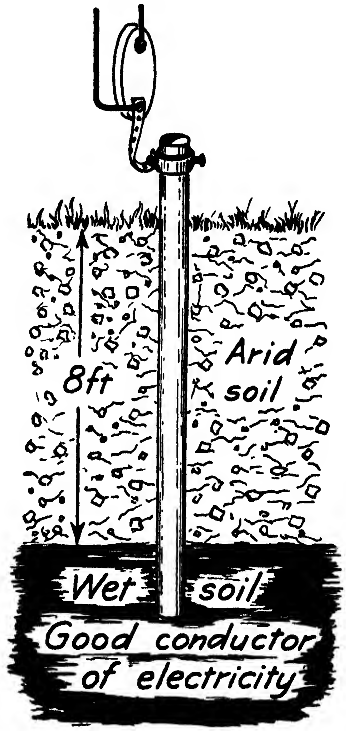


Fig. 19-43. Be sure the ground rod or pipe extends down to permanently moist soil. (Prime Manufacturing Company)

advisable to moisten it under and in front of the training wire, in order to give better ground connection and a stronger shock or sting during training.

It is important not to let weeds and brush grow up and touch the insulated fence wire, as this would ground the wire and make the fence ineffective.

Points on working with electrical equipment

1. Do not handle connected or "live" electrical equipment with wet hands or when standing on wet footing.
2. When doing wiring, be sure to do it in a safe and approved manner, as prescribed by the National Electrical Code. When in doubt

consult an electrician or an authoritative book or manual on wiring.

3. Make all splices and connections in electric wires in an approved and workmanlike manner. Loose, dirty, or poorly insulated splices are a source not only of trouble, but of danger.
4. Pull on the plug, not the cord, when disconnecting an appliance. (On some of the newer-style outlets, it is necessary to twist the plug to the left before pulling it out.)
5. Do not use cords with broken or defective insulation.
6. Keep motors and other electrical equipment free from dirt and moisture.
7. Always turn the current off at the main switch when working on a circuit.
8. Always replace a blown fuse with one of the proper size.
9. Do not investigate or work around a power transformer or a high-voltage line. In case of trouble, call the power company or utility office.
10. See that motors are properly lubricated, but not overlubricated.
11. See that motors are properly protected by time-lag fuses or by suitable thermal-overload protective devices. Ordinary fuses do not protect motors.

JOBS AND PROJECTS

1. Inspect all desk lamps and floor lamps about your home, and repair or replace any cords that are not in good condition.

2. Make an extension cord or trouble lamp. Use a bakelite or weatherproof socket to avoid the possibility of shocks when using it on damp floors.

3. Inspect the fuse cabinets about your home or farm, and make sure the proper sizes of fuses are used. Get a few extra fuses and make a place to keep them near the fuse box, so that replacements may be made quickly and easily and with the proper sizes of fuses.

4. Oil the electric motors about your home or farm. Wipe and clean them as much as possible without taking them apart. Make a calendar or schedule for oiling them in the future, and tack it up near one of the motors.

5. Disassemble and clean an electric motor. Blow out any accumulated dust and dirt with air under pressure if it is available. Clean the commutator, if it has one, and smooth it with fine (No. 00) sandpaper if it is only slightly rough. If the commutator is badly pitted or grooved, take it to a shop and have it turned true. Be careful in assembling the motor not to damage any parts.

6. Rig a small electric motor to make it portable, and arrange places where it is to be used on various jobs, so that it can be easily and quickly set in place and belted to the load.

7. Make a battery-charging outfit from an old automobile generator, arranging it to be driven with a portable electric motor.

8. Inspect all the electric motors about your home or farm to make sure they are properly protected against overload. If any motor is not properly protected, install a time-lag fuse of the proper size (not more than 15 to 20 percent larger than the current rating on the motor name plate) or a suitable overload protective device.

9. Inspect the wiring system about your home or farm, and make a list of short desirable extensions that you could install. Install one or more of these extensions, first being sure you know how to do the work safely and in an approved manner. In case of doubt, consult your instructor or an experienced electrician. Have the work approved by an electrical inspector.

10. Install a doorbell, buzzer, or chimes in your home, or a set of bells, buzzers, or chimes.

11. Install and operate an electric fence. Carefully read and observe all instructions furnished with the fence unit or controller.

12. Make an electric chick brooder, or an electric pig brooder, according to plans obtained from a bulletin or book in your school library.

CORRELATED LIST OF VISUAL AIDS

THE FOLLOWING LIST of filmstrips and motion pictures can be used to supplement much of the material in this book. The individual descriptions indicate whether the films are motion pictures or filmstrips (MP or FS), and the film lengths are indicated in minutes (min) or frames (fr). The name of the producer and also the distributor, if different from the producer, are given. The abbreviations of names are identified at the end of the lists. Unless otherwise indicated, the motion pictures are 16mm black-and-white and sound, and the filmstrips are 35mm black-and-white and silent.

While this bibliography is a selective one, it is recommended that each film be reviewed before use to determine its suitability for a particular unit of study. It is suggested also that film users examine the latest editions and supplements of *Educational Film Guide* and *Filmstrip Guide,* published by the H. W. Wilson Company, New York. These guides are available in most college and public libraries.

Chapter 2. SKETCHING AND DRAWING

Blueprint Reading (MP series USOE/UWF). Five motion pictures and correlated filmstrips with the following titles: *Visualizing an Object* (9min); *Reading a Three-view Drawing* (10min); *Principal Dimensions, Reference Surfaces and Tolerances* (12min); *Sectional Views and Projections, Finish Marks* (15min); *Reading a Drawing of a Valve Bonnet* (20min).

Mechanical Drawing (MP series McGraw). Eight motion pictures and follow-up filmstrips correlated with French and Svensen: *Mechanical Drawing.* Set 1: *Language of Drawing* (10min); *Shape Description,* Part 1 (11min); *Shape Description,* Part 2 (8min); *Shop Procedures* (17min). Set 2: *Sections* (10min); *Auxiliary Views,* Part 1 (11min); *Auxiliary Views,* Part 2 (10min); *Size Description* (13min).

Chapter 3. WOODWORK AND FARM CARPENTRY

Sawing, Planing, and Smoothing Wood (FS McGraw 36fr). Explains how to use various types of handsaws, planes, scrapers, and sandpaper. (Shopwork series)

Laying Out Common Rafters and Open Stairs (FS McGraw 39fr). Gives procedures for figuring rise, span, and pitch of rafters; shows use of right-angle triangulation and similar methods for laying out stairs. (Shopwork series)

Framing: Floor Joists and Walls (MP USN/UWF 25min). Illustrates procedures for constructing walls, floors, doors, and windows of a two-story building.

Framing: Hip and Valley Rafters (MP USN/UWF 25min). Shows how to cut, measure, and fit hip and valley rafters, and compares them with regular-type rafters.

Framing: Rafter Principles and Common Rafters (MP USN/UWF 15min). Illustrates laying out and cutting of rafters.

Fundamentals of Stair Layout (MP USN/UWF 11min). Covers the measuring, fitting, and installing of stairways.

Industrial Arts (MP series YAF). Six films, 10 minutes each, covering various woodworking tools and operations: *Boring and Drilling; Chisels and Gauges; Hand Saws; Measuring and Squaring Tools; Planes; Using Nails and Screws.*

Chapter 4. POWER WOODWORKING SAWS

Precision Wood Machining (MP series USOE/UWF). Sixteen films, with correlated filmstrips, demonstrating various operations performed with different woodworking power tools. Following are the seven titles of the subseries and individual films best suited to supplement this chapter, with running time. *Cutting Grooves with Circular Saw Blades* (22min). *Band Saw: Sawing with a Jig and Changing Band* (20min); *Sawing a Reverse Curve and a Bevel Reverse Curve* (18min). *Variety Saw: Ripping and Cross-cutting* (19min); *Beveling, Mitering, Rabbeting, and Dadoing* (19min); *Cutting Tenons and Segments* (15min); *Cutting Cove Molding and a Corebox* (19min).

Chapter 5. THE JOINTER

Beveling, Stop Chamfering, and Tapering Square Stock (MP USOE/UWF 20min). How to set fence for bevel cutting, adjust the proper

amount of cut, cut chamfer, set the infeed and outfeed tables and stop blacks, and cut tapers.

Face Planing Uneven Surfaces (MP USOE/UWF 13min). How to determine the condition of boards; correct defects on the jointer; face wide stock with a slight cross grain; make and use a feather board; and face thin stock, using a push block.

Jointing an Edge for Gluing: Installing Knives (MP USOE/UWF 21min). How to determine when knives are dull, remove dull knives, install sharp knives on the cutterhead and adjust them for proper cutting, straighten crooked stock, and join edges for gluing.

Jointing Edges and Ends 90 Degrees to Face (MP USOE/UWF 17min). Gives functions and operation of the jointer. Tells how to identify surfaces of a piece of stock, joint a square edge to size, and joint a piece of glued stock to size.

Chapter 6. PAINTING, FINISHING, AND WINDOW GLAZING

Repainting a Frame Building (MP USOE/UWF 18min). How to prepare a building for painting; set up staging; prepare paint; apply the prime and second coats; and care for brushes, paint, and equipment.

Chapter 7. SHARPENING AND FITTING TOOLS

Sharpening Hand Tools (FS McGraw 39fr). Principles of grinding, whetting, and stropping of such common tools as knives, planes, chisels, scissors, and snips. (Shopwork series)

Sharpening and Using Auger Bits and Twist Drills (FS McGraw 39fr). Explains how bits and drills cut and how they are sharpened and used. (Shopwork series)

Chapter 8. ROPE WORK

Knots (MP USCG/UWF). Nine motion pictures and correlated filmstrips demonstrating various rope knots and ties: *The Square Knot* (5min); *The Bowline* (4min); *The Sheet Bend* (3min); *Two Half Hitches and a Round Turn* (3min); *Double Carrick Bend* (3min); *The Clove Hitch* (3min); *Clap a Stopper on a Line* (3min); *Bending to a Cleat* (3min); *French Bowline* (3min).

Use and Care of Fiber Rope (MP USN/UWF 20min). Explains how to care for, inspect, and use fiber ropes; compares sisal, manila, and jute; and shows methods of splicing and eyeing.

Chapter 10. CONCRETE WORK

Foundations and Concrete (MP USN/UWF 26min). Presents a brief overview of building foundations, usually made of concrete, and mentions variables which determine the type of foundations to be used.

Chapter 11. SOLDERING AND SHEET-METAL WORK

Soldering (FS McGraw 35fr). Shows how to solder seams, electrical splices, and small holes. Includes cleaning surfaces, applying fluxes, and using plain and electric soldering irons and blowtorches. (Shopwork series)

Hand Soldering (MP USOE/UWF 20min). Gives the theory of soldering and tells how to prepare soldering irons and torches, clean and prepare the work, fasten joints, solder wire and lug joints, and seal seams.

Chapter 12. COLD-METAL WORK

Filing and Hacksawing (FS McGraw 41fr). Shows kinds of files and their uses and hack-saw blades for different kinds of cutting. Tells how to use files and hack saws. (Shopwork series)

Shop Tools (MP series USA/UWF). Six films demonstrating the uses of specific tools and explaining the precautions of be followed in their use: *Bars, Punches and Drifts* (15min); *Chisels* (12min); *Hacksaws* (18min); *Hammers* (12min); *Pliers and Screwdrivers* (15min); *Wrenches* (19min).

Blanking Sheet Metal with Hand Snips (MP USOE/UWF 18min). How to cut along a straight line; how to cut an outside circle, a notch, an inside line; and how to remove burrs left by cutting.

Filing Template Metal (MP USOE/UWF 15min). How to file a square edge and remove burrs, rotate the wrist for filing inside curves, file inside rectangle, and remove fillets from corners.

Metalworking (FS series McGraw). Five filmstrips with the following definitive titles: *Bench Metal: Cutting* (38fr); *Bench Metal: Drilling*

(37fr); *Bench Metal: Filing* (42fr). *Sheet Metal: Bending* (50fr); *Sheet Metal: Laying Out and Cutting* (38fr).

Chapter 13. THE METALWORKING LATHE

Basic Machines: The Lathe (MP USOE/UWF 15min). Functions, characteristics, and basic operations of the engine lathe. Correlated filmstrip, 49 frames. See also motion picture and related filmstrip on *The Drill Press* (10min).

Operations on the Engine Lathe (MP series USOE/UWF). Seventeen films and correlated filmstrips depicting specific uses of a metalworking lathe: *Rough Turning between Centers* (15min); *Turning Work of Two Diameters* (14min); *Cutting a Taper with the Compound Rest and with a Taper Attachment* (11min); *Drilling, Boring, and Reaming Work Held in Chuck* (11min); *Cutting an External National Fine Thread* (12min); *Turning a Taper with the Tailstock Set Over* (17min); *Cutting an External Acme Thread* (16min); *Cutting an Internal Acme Thread* (22min); *Cutting an Internal Taper Pipe Thread* (20min); *Turning Work Held on a Fixture* (21min); *Boring to Close Tolerances* (17min); *Machining Work Held in Chuck: Use of Reference Surfaces* (24min); *Turning Work Held on a Mandrel* (20min); *Using a Steady Rest* (25min); *Using a Follower Rest* (21 min); *Using a Boring Bar between Centers: Work Held on Carriage* (22min); *Using a Steady Rest When Boring* (21min).

Chapter 14. FARM BLACKSMITHING

Blacksmithing (FS McGraw 42fr). Covers such operations as bending, drawing, and hammering; forging tool steel; and annealing, hardening, and tempering. (Shopwork series)

Basic Blacksmith Operations (MP USA/UWF 26min). Explains and demonstrates various blacksmithing operations with emphasis on the use of tools and equipment. Discusses the advantages of side-banked, plain-open, and deep-hollow fires.

The Blacksmith: Calculating and Bending Rings and Links (MP USN/UWF 21min). Teaches elementary shipsmithing including linear calculation of stock, formation of rings and links, forge welding, and the use of common hand blacksmith's tools.

Forge Welding (MP USOE/UWF 12min). How to maintain a clean, deep, hot fire; heat mild steel for forging; upset and scarf round stock; make a lap weld; and shape and hammer-refine the weld.

Forging with a Hand Forge (MP USOE/UWF 13min). How to clean the tuyère and build an open fire in a forge, lay out and mark the stock, heat mild steel for forging, and forge an eye.

Sharpening and Tempering Farm Tools (MP USOE/UWF 17min). How to heat carbon steel tools for forge sharpening; sharpen, harden, and temper a plowshare and a cultivator shovel; and identify tempering colors.

Chapter 15. PIPEWORK AND SIMPLE PLUMBING

Pipework and Simple Plumbing (FS McGraw 29fr). Covers measuring and cutting pipe; reaming, threading, and assembling; installing copper tubing; and repairing valves and faucets. (Shopwork series)

Cutting and Threading Pipe by Hand (MP USOE/UWF 12min). How to use a pipe cutter and pipe reamer, select and insert proper dies in stock, thread pipe by hand, test threads for fit, prepare fitted pipe for delivery, and care for tools.

Measuring Pipe, Tubing, and Fittings (MP USOE/UWF 15min). How to identify types of pipe, tubing, and fittings; use basic measuring tools; measure pipe for offsets; and make allowances for fittings and offsets in measuring pipe.

Chapter 16. ELECTRIC ARC WELDING

Electric Arc Welding (FS McGraw 28fr). Explains the principles of arc welding, types of welds, use of the arc torch, and cutting with an electric arc. (Shopwork series)

Chapter 17. OXYACETYLENE WELDING AND CUTTING

Oxyacetylene Welding and Cutting (FS McGraw 41fr). Shows the preparation of parts for welding and covers welding steel and cast iron, repairing castings, bronze welding, and cutting steel and cast iron. (Shopwork series)

How to Weld Aluminum (MP USBM). Three motion pictures sponsored jointly by the U.S. Bureau of Mines and Alcoa: *Arc Welding*

(10min); *Resistance Welding* (12min); *Torch Welding* (17min).

Oxyacetylene Cutting and Welding (MP series USOE/UWF). Five motion pictures and correlated filmstrips with the following titles: *Manual Cutting to a Line: Freehand* (21min); *Manual Cutting a Bevel: Freehand* (13min); *Manual Cutting a Shape: Freehand Guided* (16min); *The Guided Bend Test* (17min); *Oxyacetylene Welding: Light Metal* (21min).

The Oxyacetylene Flame, Master of Metals (MP USBM 19min color). Shows how oxygen and acetylene are blended to form a flame to cut, weld, solder, braze, and harden metal. Demonstrates the forming of teeth on tractor gears, welding gray cast iron, hardening the working edge of plows, and joining metals by fusing melted bronze.

Welding Comes to the Farm (MP Lincoln 24min). Dramatized presentation of the importance of welding in repairing and rebuilding farm equipment.

Welding on the Farm (MP GE 20min color). Illustrates the many uses of a portable arc welder on the farm. Fundamentals of arc welding are explained and demonstrated.

Chapter 18. REPAIRING AND RECONDITIONING MACHINERY

Care and Repair of Hand Tools (FS McGraw 29fr). How to care for tools when in use and in storage and how to keep them in good working condition. (Shopwork series)

Reconditioning a Cultivator (MP USOE/UWF 14min). How to replace a worn wheel boxing; adjust yoke; check and adjust shovels; check and lubricate gang expansion and steering assemblies; and lubricate all parts of a cultivator.

Reconditioning a Grain Drill (MP USOE/UWF 31min). How to inspect and repair a typical grain drill; clean and lubricate the fertilizer and seeding mechanism; repair the disk furrow openers, drive chains, pawl assembly; and calibrate the seeding mechanism.

Reconditioning a Mower. Part 1: Cutter Bar (MP USOE/UWF 21min). How to repair the sickle; repair and adjust the guards; mount and align the cutter bar; and check the mower's operation.

Reconditioning a Mower. Part 2: Drive System (MP USOE/UWF 21min). How to clean, inspect, lubricate, and replace the wheel assembly; replace a worn wrist pin; disassemble and inspect the gear assembly;

check and remove, if worn, flywheel shaft bearings and install new bearings; and lubricate the reconditioned mower.

Reconditioning a Two-bottom Tractor Plow (MP USOE/UWF 25min). How to check and repair the wheel assemblies and the power lift assembly; recondition the plowshares; adjust the colter; and check and adjust the furrow wheels in the field.

Chapter 19. MAINTAINING ELECTRICAL EQUIPMENT

Using Electricity Safely (FS McGraw 33fr). Cautions in using and repairing common electrical equipment such as splicing, taping, repairing cords, and replacing switches. (Shopwork series)

SOURCES OF FILMS LISTED

GE—General Electric Co., Schenectady, N.Y.
Lincoln—Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio.
McGraw—McGraw-Hill Book Co., Inc., Text-Film Dept., 330 West 42d St., New York 36, N.Y.
USA[1]—U.S. Department of the Army, Washington 25, D.C.
USBM—U.S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.
USCG[1]—U.S. Coast Guard, Washington 25, D.C.
USN[1]—U.S. Department of the Navy, Washington 25, D.C.
USOE[1]—U.S. Office of Education, Washington 25, D. C.
UWF—United World Films, 1445 Park Ave., New York 29, N.Y.
YAF—Young America Films, 18 East 41st St., New York 17, N.Y.

[1] Films distributed by United World Films.

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